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Evaluation of the effect of the Bristol Pecking Pan on beak sharpness of pullets during rear

Evaluation of the effect of the Bristol Pecking Pan on beak sharpness of pullets during rear.

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Abstract

One of the most challenging issues in commercial egg production is Injurious Pecking (IP), which is identified by the pecking or pulling of the feathers or flesh of another flock member. This can cause distress, feather loss or even death. Currently, beak trimming (BT) is a widespread practice to help reduce damage. As IP is thought to develop from thwarted foraging, one approach to managing it is to improve or 'enrich' the birds' environment by providing a long-lasting environment enrichment with the added benefit of blunting the bird's beak naturally. This study investigated the effect of provision of pecking pans during rear on feather cover, injurious pecking behaviour and beak lengths, also examining breed influences. Sixteen commercial flocks were used: British Blacktail (n=8), Lohmann Brown (n=6) and Bovans Brown (n=2). Flock size ranged from 3,300 – 11,000 (mean 6,843). Half of the 16 flocks were beak trimmed (BT) at day old at the hatchery and the other half were intact beak flocks. Pecking pans were supplied by 6 weeks of age to 4 BT and 4 intact beak flocks to give a 4x4 experimental design. This study demonstrated that pecking pans for chicks/pullets may provide an environmental enrichment with the potential of blunting the bird's beak naturally through normal levels of wear at approximately 10/11 weeks of age. Levels of IP were low and did not vary significantly with age, breed or presence of the pan. A reduction of plumage damage in some body areas such as tail and wing was seen at 14-15 weeks of age in flocks with access to pecking pans. Furthermore, results indicate genotypic variation in beak characteristics, which gives scope for selecting for genotypes with less damaging beaks.

Dedication and Acknowledgements

Today is the day, I am writing this note of thanks for the finishing touch on my thesis. It has been a period of intense learning both on a scientific and personal level. Writing this thesis has not only broaden my knowledge in chickens but also given me the opportunity to study a subject I am exceptionally passionate about. I would like to reflect on the people who have supported and guided me throughout my studies.

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Author’s Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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List of abbreviations

AP = Aggressive Pecking

BB = Bovans Brown

BT = Beak Trimming

BTAG = Beak Trimming Action Group

BBT = British Black Tails

CB = Cannibalistic Behaviour

CIWF = Compassion in World Farming

FAWC = Farm Animal Welfare Council/Committee

GFP = Gentle Feather Pecking

HB = Hot Blade

H = Hyline

IP = Injurious Pecking

IRBT = Infra-red Beak Trimming

KW = Kruskal-Wallis

LBC = Lohmann Brown Classic

LB = Lohmann Brown

LSL = Lohmann Selection Leghorn

MWU = Mann-Whitney U

PD = Plumage Damage

SD = Stocking Density

SFP = Severe Feather Pecking

SPSS = Statistical Package for the Social Sciences

SRUC = Scotland Rural College

UK = United Kingdom

VP = Vent Pecking

1. Introduction

Chickens have been domesticated for at least 8000 years (Nicol, 2015). They are the most common of all domesticated animals, kept both for eggs and as a source of relatively inexpensive meat. Their wild ancestor was the junglefowl and four main species have been recognised; *Gallus gallus* (red junglefowl), *Gallus varius* (green junglefowl), *Gallus sonneratii* (grey junglefowl) and *Gallus lafayetii* (Ceylon junglefowl) (Al-Nasser *et al*, 2007). It is the red jungle fowl which produced 10 - 15 eggs per year that is the main progenitor of domestic chickens (Al-Nasser *et al*, 2007). Owing to the high demand for higher egg production, selection has focused on productivity, with commercial laying hens now laying 300 eggs per year (Al-Nasser *et al*, 2007) with a continued drive by breeding companies to produce birds that lay 420-430 eggs by 90 weeks of age (Hendrix-genetics, 2018).

The laying hen industry estimates there were 35 million laying hens in the UK in 2015. The latest figures in August 2017 showed that the UK produced 10,546 million eggs per year (egginfo, 2016). The UK consumption for 2016-2017 was 12,813 million eggs, making the UK 85% self-sufficient. In 2016, the industry estimated the retail value of the egg market in the UK was £910m (egginfo, 2016).

Over the years, there has been an increase in the proportion of free-range eggs sold in the UK due to consumer choice and demand. As the market stands currently, the percentage of birds housed in each housing system is 48% caged birds, free-range 50% including 2% organic and 2% barn (egginfo, 2016). Due to the increase in consumers wanting to buy welfare friendly and free-range eggs, the free-range egg industry has become more intensive, with much larger production scales. Laying hens are loose housed, with larger-scale sheds housing flock sizes of up to 64,000 birds, and sites with four or more sheds now increasingly common.

All systems of egg production generate welfare challenges. One of the most problematic issues in commercial egg production is Injurious Pecking (IP). IP is primarily a redirected foraging behaviour which can be displayed by laying hens. It is identified by the pecking or pulling of the feathers of another flock member which can cause distress, feather loss or even death. It requires considerable effort, husbandry and management skills to maintain an environment in which this behaviour is less likely to occur. If an outbreak of severe IP occurs, resultant high mortality rates are a welfare issue that can be commercially damaging. Nicol *et al,* (2013) recently reviewed a range of fundamental studies and concluded that IP is prevalent in all housing systems: conventional cages, furnished cages, barn and free-range systems. However, the spread of IP behaviour between birds is more of a problem in loose housing systems than in cage systems, where perpetrators have access to more victims. Currently, IP is controlled by beak trimming (BT). This practice has been used in commercial poultry, turkeys and game birds for over 60 years to reduce the sharpness of the beak (Kuenzel, 2007). Issues related to BT remain controversial worldwide and still provoke a great deal of debate from an animal welfare perspective. Research has shown both the advantages and disadvantages of this practice and its impact regarding bird welfare.

An alternative approach to managing IP might be to improve or 'enrich' the birds' environment. Studies of environmental enrichment originated in the 1960s and 1970s with a focus on brain development and function. Environmental enrichment was first mentioned as a possible approach to improving animal welfare in 1985 by the United States Animal Welfare Act and was generally focused on nonhuman primates (Adams, 2007). It rapidly became widespread in zoos and research institutions for other captive species. It is critical that enrichment can be independently shown to improve animal welfare rather than simply increasing the complexity of an environment (Newberry, 1995). Enrichment is now applied in poultry management settings to encourage chickens to express natural behaviours and help to discourage unwanted behaviours such as IP. Many studies suggest that providing enrichment devices for chicks or pullets could be a useful way of directing their pecking behaviour to harmless substrates (Lambton, *et al,* 2013; Dixon *et al*, 2010, Huber-Eicher & Wechsler 1998, Blokhuis, 1989). Another potentially important function of enrichment devices could be to blunt the birds' beaks naturally through normal levels of wear. However, research on enrichment devices to aid beak bluntness remains very limited.

The literature review for this thesis will review different aspects of the problem of IP and describe methods used to date to try to limit the damage caused. The pros and cons of different beak trimming methods will be reviewed. The review will finish by outlining the aim and objectives of my work, namely to trial a beak blunting enrichment to reduce the sharpness of the beak as alternative approach to beak trimming.

2. Literature Review

2.1 Injurious pecking during the laying phase

It is understood that IP is a behaviour problem which may reflect an unfilled behaviour need for pecking in birds (Rodenburg *et al*, 2013, Huber-Eicher and Wechsler 1997, Duncan and Hughes, 1972). The consensus is that IP reflects a redirection of normal foraging or exploratory pecking from an appropriate substrate to the plumage of other birds, with damaging consequences (Blokhuis and Arkes, 1984). It is not only a problem for the recipient being feather pecked but may also indicate a lack of a stimulating environment for the birds which are responsible for the behaviour (Morrissey *et al*, 2016). It has been identified in many studies that IP is a multifactorial problem and can be triggered by an abundance of risk factors; environment, nutrition, genetics and breed, as discussed in comprehensive reviews by Nicol *et al,* (2013) and Rodenburg *et al, (*2013).

Hens under natural conditions can spend between 35 to 50% of each day in foraging activity (Folsch *et al*, 2002). IP can be identified by the pecking or pulling of the feathers of another flock member. Light, gentle feather pecking (GFP) generally aimed at the tip of the tail results in little damage causing little welfare concern. However severe feather pecking (SFP) is using the beak to peck and pull out the feathers of other birds with force, resulting in damage or plumage loss causing pain, fear and distress to the recipient bird (De Hass *et al,* 2010; Lambton *et al*, 2010). Vent pecking (VP) is targeted solely at the vent area and tends to start when the birds come into lay (Nicol *et al,* 2013). This can lead to severe wounds and birds are attracted to the exposed skin, which may lead to cannibalistic pecking (CB) (Appleby *et al*, 2004, Blokhuis and Arkes, 1984). It has also been witnessed that some birds peck and pull out the feathers before eating them, which may indicate a dietary deficiency (Kjaer and Bessei, 2013, Blokhuis and Arkes, 2004). Hens can also display aggressive behaviour towards one another and this is generally targeted at the head or neck region, but this doesn't fit under the umbrella of IP as it is thought to have different underlying motivation (Morrissey *et al*, 2016, Lambton, 2008).

A survey reported that 47% of UK free-range farmers had regularly witnessed IP and 57% of them had seen it in their last flock (Green *et al,* 2000). Recently a study by Lambton *et al*, (2010) found that out of 111 loose housed systems at 40 weeks, the clear majority (86%) of flocks contained hens that demonstrated SFP behaviour. IP has been shown to be heritable with some genetic lines having the tendency to peck more at conspecifics (Rodenburg and Koene, 2002). Studies have indicated that there are high feather peckers (HFP) and low feather peckers (LFP). HFP have been shown to perform higher levels of SFP, GFP and vocalisation. It has been witnessed that LFP perform more ground pecking behaviour than HFP (Rodenburg and Koene, 2002). Some research has proposed that GFP is correlated to SFP, but other researchers have found no correlation (Morrissey *et al*, 2016).

2.1.1 Injurious pecking during the rearing phase

Research by Adret, Hausberger and Cumming (1987) on feeding and growth of birds suggested that the foraging activity of pecking and ground scratching can be motivated by previous experience during the rearing process. Earlier studies have witnessed GFP in chicks as early as a day old (HuberEicher, 1999). An epidemiological survey reported that farmers in Switzerland estimated 37.5% of young pullets performed IP (HuberEicher and Sebo, 2001). However, researchers observing the flocks reported 40% of flocks had developed IP activity by week 5 and by the end of the rearing period at 14 weeks IP was seen in 77.3% of pullets (HuberEicher and Sebo, 2001). More recent findings support the view that IP is widespread during the rearing period (Gilani *et al*, 2013, Lambton, 2008).

Young pullets generally start pecking around the preen gland and oily feathers near the tail (Appleby *et al,* 2004). Gilani *et al*, (2013) found that GFP was witnessed at a week old in 34 flocks visited. In addition, SFP was demonstrated by 21 flocks of the 34 and it was prominent in 14 flocks at 16 weeks. Comparable results were found by Lambton (2008), who reported that both GFP and SFP activity occurred in flocks at 10 weeks of age. Several studies have emphasised the importance of the rearing environment to reduce IP at lay.

2.2 Beak Anatomy

The chicken's beak is an all-purpose tool used for several tasks from foraging for food, to the preening of feathers and nesting behaviour (Fiks-van Niekerk and de Jong, 2007). The beak comprises an upper beak (*Rostrum maxillae*) and a lower beak (*Rostrum mandibular*). Both the upper and lower beak are made up of bone. The premaxilla bone of the upper beak and the mandibular bone of the lower beak are covered by a dermis. The dermis which extends right down to the beak tip is made up of collagen, elastin fibres, muscle, blood vessels, nerve fibres and sensory nerve endings. The outer layer of the beak consists of a horny keratinized sheaf (*stratum corneum*) that covers the upper and a lower beak which can act as a tool or 'weapon' for offensive and defensive behaviour (Icken *et al,* 2017; Fiks-van Niekerk and de Jong, 2007, Jendral *et al,* 2004). Along the horny sheaf (*Margines rostri*) lies a sharp but generally a smooth edge which becomes much thicker near the beak tip (*Apex rostri*) (Fiks-van Niekerk and de Jong, 2007). The chicken's beak has several receptors which are sensitive to tactile stimuli, vibrations, heat, cold and noxious substances (Cheng, 2006, Fiks-van Niekerk and Elson, 2004). On the upper beak near the beak tip are concentrated mechanoreceptors. These sensory receptors work by identifying mechanical changes such as mechanical pressure or distortion (Gentle *et al,* 1997). They can also be found in the lower beak along with free nerve endings which are found in dermal papillae. It is in the lower mandible that gives the bird the sensitivity of manipulating and evaluating objects (Cheng, 2006). The free nerve ends found in the tip of the upper beak and beak organ on the lower beak resemble the nociceptors found in mammals and it is these receptors that sense damage or injury to the beak (Gentle *et al,* 1997). The beak has thermoreceptors and it is these specialised nerve cells that detect variances in temperature. Further studies by Freire (2011), Falkenberg *et al*, (2010) indicate that chickens like other avian species may have magnetoreceptors in the beak. This is due to findings of magnetite particles of iron mineral deposits found in the upper beak and that chickens have shown to use directional information from the magnetic field of the earth to orient in rather small areas (Falkenberg *et al*, 2010).

2.3 Beak Trimming

Most laying hens in the UK are beak trimmed, except for some birds produced organically or supplying a higher welfare market. Beak trimming (BT), otherwise referred to as beak tipping in the UK, is one of the most consistent techniques that reduce the impact of IP including vent pecking and cannibalism (Glatz, 2000). BT involves the removal of up to one third of the upper and lower beak, (RSPCA, 2013; Appleby, 2004, Jendral *et al,* 2004) which includes the horny beak and the underlying tissue (Cheng, 2006, Appleby, 2004). There are generally two methods: the hot blade technique (HB) still widely used outside of the UK and the Infra-red technique (IRBT) which has replaced HB trimming in the UK and some other countries including the Netherlands (Spoolder *et al*, 2016).

2.3.1 Hot Blade Technique

Hot blade (HB) trimming machines have been widely utilised for over 50 years for laying hens, broilers and turkeys (Glatz, 2000). The use of the HB procedure still causes debate worldwide as considerable research has indicated this method of trimming may cause acute and chronic pain particularly in laying hens (Dennis *et al,* 2009). The trimmer resembles a heated guillotine blade that cuts the beak while cauterizing at the same time (Dennis *et al,* 2009; Appleby, 2004, Glatz, 2000). The temperature is generally gauged by the colour of the blade with the option of thermocouples to measure its temperature. A dull red colour indicates temperature in the region of 605 – 750°C. With this technique birds are trimmed without any pain relief at around 5 to 10 days of age, but if regrowth appears an additional re-trim may occur at 5-8 weeks (Glatz, 2000). It has been witnessed that a trimmed beak can in fact grow back to its original length over time (Fiks van Niekerk and Elson, 2005). However, the beak tip will not be as sensitive as before, as the nerve endings and receptors do not penetrate the scar tissue (Fiks van Niekerk and Elson, 2005).

2.3.2 Infra-red Technique

The Infra-red beak trimming (IRBT) method was developed to reduce pain and to provide a more accurate technique with less potential for human error than hot blade trimmings (Dennis *et al,* 2009). It was first introduced in 1985 and is now widely used in the US and throughout some European countries. IRBT is performed without any pain relief and generally undertaken on day-old chicks at the hatchery. The chicks are suspended, and their heads are firmly restrained in a rubber holder, preventing all movement. The holders can be adapted for different breeds of birds and the infra-red beam can be adjusted according to beak size (Gentle and Mckeegan, 2007). The method employs an infra-red laser beam which is directed at the tip of the beak (Appleby, 2004). The intensified heat then penetrates down through the layer of the horny keratinized (*stratum corneum*) layer that covers the upper (*Rostrum maxillae*) and lower beak (*Rostrum mandibular*). This intense heat encourages the stratum corneum to generate basal tissue and prevents additional germ layer growth (Dennis *et al*, 2009). The infra-red treatment takes approximately 1.5 seconds, with the entire treatment lasting no longer than 15 seconds in total (AVMA, 2010). Post treatment, the beak remains intact for up to 7-10 days before the beak tip wears away (Dennis *et al*, 2009). However, sometimes the beak tip can take up to three weeks to finally drop off (BTAG review, 2015; Appleby, 2004). The IRBT method has many benefits; primarily it eliminates open wounds in comparison to HB treatment. Evidence has shown that beak shape and length characteristics change gradually over a two-week period (Dennis *et al*, 2009) and it is also more effective in reducing beak regrowth (Marchant-Forde and Cheng, 2010). Another positive aspect of IRBT compared with HB method is that it reduces multiple stressors for the chicks in the reduction of additional catching and handling (Dennis *et al*, 2009). The cost of both methods of BT back in 2010 was identified at 3p per bird. This cost is passed on to the pullet rearer and then further down the line to the egg producers (Gov.UK, 2010).

2.3.3 Benefits and Implications of Beak Trimming

BT remains one of the most effective management tools to reduce the impact of IP including vent pecking and cannibalism (Nicol, 2015, Glatz, 2000). A beak trimmed bird inflicting IP will cause less damage and pain to the recipient bird. This typically means less plumage damage as beak trimmed birds tend to perform less effective feather pecking and feather pulling behaviour (Fiks-van Niekerk and de Jong, 2007). This reduces trauma to the receiver and reduces disease and chronic stress (Hughes and Gentle, 1995).

Studies have long established that young chicks that have been beaked trimmed can be shown to have good feed consumption, conversion rates (Jendral *et al,* 2004, Glatz, 2002), good plumage cover and lower mortality rates (Fiks-van Niekerk and Elson, 2005). However, there are welfare implications of BT and studies reveal that all methods have negative aspects and have highlighted concerns for poultry welfare. Welfare implications can reduce feed intake and a reduction in beak-related behaviours due to short and long-term pain (Fiks-van Niekerk and Elson, 2005). Research has shown that the influence of BT does vary with breed, procedure used and age of trimming (Fiks-van Niekerk and Elson, 2005).

2.3.4 Feed Consumption, Conversion Rates and Growth

There are contradictory findings concerning the effect of BT on feed conversion and growth. BT can help reduce food consumption and feed wastage (Glatz, 2002), but this is not always wholly positive. As chicks that are beak trimmed at an early age can also have decline in growth rate (Jendral *et al,* 2004, Hughes and Gentle, 1995). Feed intake and growth reduction can still be seen several weeks post treatment (Kuenzel, 2007), although once the bird reaches sexual maturity weight gain returns to normal (Craig & Lee, 1990). Birds that were beak trimmed at a day old by HB or IRBT reached sexual maturity faster than intact flocks (Honaker and Ruszler, 2004). Andrade and Carson (1975) observed the effect of age and methods of BT on future performance of white leghorn pullets. The pullets were beak trimmed by the HB technique at either 1 day old, 6 days old, 6, 8, 12 or 16 weeks of age. The study found a significant reduction in feed consumption in birds that had been beak trimmed at 1 and 6 days old. Birds that had been beak trimmed at 6 days old also showed a significant reduction of feed intake at 20 weeks but later showed no difference in egg production and egg size. The day-old beaked trimmed birds showed a reduction in feed consumption by 475g per pullet and a 118g drop in body weight up to 35 weeks of age. However, birds trimmed at an older age of 12 or 16 weeks produced much smaller eggs in comparison to birds trimmed at an earlier age and showed a reduction in bodyweight. A similar result was seen in a study by Honaker and Ruszler, (2004) where IRBT day old birds ate less feed and lower bodyweights were seen. A paper by Prescott and Bonser, (2004) emphasised that BT can reduce feeding efficiency in laying hens. They concluded, after observing highspeed video filming of feeding birds, that beak trimmed hens found it problematic when trying to eat pelleted feed from a single layer of feed with a connection to beak irregularity and an association with feed deprivation. A similar result was observed in a study by Gentle *et al,* (1980) suggesting beak trimmed birds failed to grasp pelleted feed even though pecking rate heightened after the procedure but resumed to normal after 3 weeks signifying no loss of motivation to feed.

2.3.5 Mortality Rates and Injurious Pecking damage

BT significantly reduces the occurrence of mortality in laying hens (Jendral *et al,* 2004). Andrade and Carson (1975) noted that all groups of birds trimmed by a HB had lower mortality than control birds which had intact beaks. Kuo *et al,* (1991) found that as the amount of the upper beak removal increased, egg production and mass was considerably improved, and beak-inflicted mortality decreased. BT by either method of HB and IRBT at lay resulted in a reduction in IP (Lambton *et al,* 2010). Similar research by Blokhuis and Van Der Haar (1989) stated that IP was significantly less damaging when performed by beak trimmed birds ($P < 0.05$) in comparison to birds with intact beaks. This was also highlighted in a study by Sun *et al*, (2013) who found that SFP was more prevalent in intact flocks suggesting that IP could therefore be a contributory factor to high mortality losses. A recent study Riber and Hinrichsen (2017) found a prevalence of high mortality in intact barn flocks averaging 14.2% in comparison to beak trimmed flocks of 8.6% from placement to depopulation. The prevalence of IP and high mortality remains a welfare problem as a recent meta-analysis of ten studies reported cumulative mortality (CM) was higher in flocks with intact beaks, than in those with trimmed beaks (Weeks *et al*, 2016). This finding is consistent with other studies and reviews.

At rear, birds that are beak trimmed generally show a reduction in IP (Lambton *et al,* 2010; Craig and Lee, 1990, Kuo *et al*, 1991). However, this advantage has to be considered alongside possible problems and techniques used. Craig & Lee (1990) found that chicks that were trimmed at a day old had higher levels of mortality. These findings were also seen by Honaker and Ruszler (2004), who found that birds that had been beak trimmed by IRBT method had higher mortality throughout the study when the birds were trimmed at a day old in comparison to birds trimmed at 7 days, which highlights that trimming birds at an older age may reduce mortality. Yet, Damme & Urselmans, (2013) found this was short lived as IRBT reduced cumulative mortality by 50% overall compared to HB and controls of intact flocks. While, a study by Lee *et al,* (1991) found that chicks BT by HB at a day old had reduced mortality at lay but no difference was witnessed when chicks were trimmed at 4 and 8 weeks compared to intact controls indicating early beak trimming could be beneficial. Again, this was observed in a study by Gentle *et al,* (1997). Domestic layer chicks that were routinely beak trimmed by HB method before 10 days old there was a decrease in cannibalism indicating that BT had a beneficial effect. A recent comprehensive review by (Janczak and Riber, 2015) highlighted that studies have indicated that IRBT is more precise compared to the HB method. However, still little knowledge on acute pain has been recorded on chicks as young as 2 days old that have been trimmed by infra-red. It has been emphasised by studies that BT should be performed before one week old to reduce long-lasting effects (Janczak and Riber, 2015).

2.3.6 Plumage Cover

Plumage Damage (PD) is widely used as a proxy measure of IP behaviour, although it should be recognised that PD can also be influenced by various factors including genetics and the rearing period (Hartcher, *et al,* 2015; Sepeur *et al,* 2015**,** Gilani *et al*, 2010**,** Lambton *et al*, 2010). Sometimes PD is not recognised during rear because the birds go through a complete moult followed by three partial moults before 16 weeks (Bestman *et al*, 2011). PD or incomplete moults to the wing and tail feathers can affect flight and cause difficulties in flight navigation (Riber and Hinrichsen, 2017) which can lead to keel bone damage (Donaldson *et al*, 2012).

It is well documented that birds that are beak trimmed have better plumage cover (Riber, *et al*, 2017; Sun *et al*, 2014, Lambton *et al*, 2010, Fiks-van Niekerk and de Jong, 2007). Blokhuis and Van Der Haar (1989) emphasised that birds that were beak trimmed had good feather cover despite IP activity. This was also supported by a study by Hartcher, *et al,* (2015) who found that beak trimmed birds had better plumage cover at 43 weeks compared to intact flocks at the same age where 72.9% of the birds had large amounts of feather loss, wounds and missing flesh on the back, rump and tail. This conclusion was also supported by Sun *et al*, (2014) although, the study additionally found that beak trimmed birds had a larger variation of PD in comparison to the intact flock indicating that IP still occurs despite BT. A recent study by Riber *et, al*, (2017) found that beak trimmed birds again had better plumage cover throughout the study but indicated that feather condition does deteriorate with age regardless if the birds are beaked trimmed or not, which has been supported in various studies. PD can also be caused by abrasion by furnishings in the shed, such as perches, feed troughs or even other birds (Sepeur *et al,* 2015), therefore it is useful to also observe bird behaviour to establish the cause of feather loss.

2.4 Pain

The widely accepted definition of pain in humans is “Pain is an unpleasant sensory *and* emotional experience that is associated with actual or potential tissue damage or described in such terms” (The International Association for the Study of Pain, 1973). It is difficult to assess pain in animals as they cannot verbally tell us, and the emotional experiences of animals are complex to study.

Zimmermann (1986) has proposed a working definition of pain in animals:

“*Pain in animals is an aversive sensory experience caused by actual or potential injury that elicits protective motor and vegetative reactions, results in learned avoidance, and may modify species specific behaviour, including social behaviour*”

As humans we have tendency to project our own experiences of pain to our assessments of animals (Gebhart, 2000). We should always strive to assess what the animal is experiencing and not our own feelings (Cheng, 2006). It is a fundamental question as to whether we can ever measure the subjective component of pain, or just use proxy measures that we assume are likely to indicate pain. Efforts have been made by developing physiological pain assessment tools (Rutherford, 2002) and observing animal behaviour. However, at present only a few methods have been validated. Identifying and measuring pain remains subjective and challenging (Allweiler, 2016).

We do know that pain perception in birds and mammals depends on the presence and activation of receptors known as nociceptors. It is these that respond to noxious stimuli, which in turn produces physiological and behavioural changes indicating that pain may have been experienced (Allweiler, 2016). These nociceptors have been detected in areas of the chicken’s body including beak, mouth, nose, joint capsule and scaly skin. So, the existence of nociceptors would imply that poultry have the basic capacity to experience pain (Gentle, 2011). Tests have also been conducted to assess affective state, and to assess internal physiological changes or neural processes to access pain. Other lines of work have examined the extent to which injured chickens will select analgesic drugs, or places associated with the experience of taking an analgesic drug (Nasr *et al*, 2013, Danbury *et al,* 2000). Nasr *et al*, (2013) found for example that hens with damaged keel bones would select an environment previously associated with analgesia. These sorts of experiments which examine birds' valenced responses provide suggestive evidence that they are able to experience pain.

2.4.1 Pain associated with beak trimming

Much research has stated that BT is a welfare problem as it has been associated with both acute and chronic pain (Cheng, 2006; Hughes and Gentle, 1995). Evidence has shown BT can cause tissue damage, nerve injury and the development of neuromas after 4-5 weeks of age (Marchant-Ford *et al,* 2008, Cheng, 2006). Birds have been shown to perform pain-related behaviours (Marchant-Ford *et al,* 2008, Gentle, 1986). The effect of BT does vary with age, procedure used, the severity of trimming and breed (Fiks-van Niekerk and de Jong, 2007).

2.4.2 Pain associated with hot blade trimming

Chicks that have been beak trimmed by HB seem likely to suffer from short and long-term pain. This technique has been found to cause beak sensitivity and sometimes the loss of beak functions (Nicol *et al,* 2013, Gentle, 2011). Studies have presented findings that the HB procedure can cause facial injuries and tongue and nostril burning, which in some cases have led to the death of the chick (Glatz, 2000). The technique has also shown excessive bleeding through open wounds, inflammation and infection (Marchant-Ford *et al,* 2008). It has been witnessed that wounds and necrotic beak tissues remained 2-3 weeks after the procedure, suggesting long-term pain (Marchant-Ford *et al,* 2008). Damage to the tissues and the nerve endings has also been seen when the beak is drawn from the blade (Jendral and Robinson 2004). Chicks have been shown to suffer from acute pain responding with vocalisation with the HB method (Jendral and Robinson 2004). Inadequate techniques have caused injury to the beak stump from cauterisation (Cheng, 2006). Physiological measures have indicated an increase in heart rate when the procedure is performed, which is likely to indicate acute stress in association with pain (Gentle, 2011). However, it is considered that there is only a short period of pain if the procedure is performed on day old chicks. This is because the peripheral trigeminal afferent nerve fibres after the HB trimming exposes an injury discharge but only for a very short period. During this time the trigeminal nerve showed no difference in neural activity for a period of up to 4 to 5 hours (Gentle, 2011). This finding was also seen by Gentle and McKeegan, (2007) during a behavioural study where day old chicks showed no substantial effects during the first hour through to 6 weeks after HB trimming. Trimming chicks at a day old does not allow neuroma formation or scar tissue to form and promotes fast beak regrowth (Gentle, 2011).

Various studies on older birds have suggested that the HB procedure causes chronic pain (Gentle, 2011). There is evidence that the beak heals fast and does not regenerate, causing scarring to the beak tip (Gentle, 2011). Breward and Gentle (1985) showed that 10 days after HB trimming the damaged nerve fibres started to redevelop causing the end of the nerve to increase in size. By 15 days after trimming, some of the beak stump had formed neuromas and, with the continuation of redeveloping nerve fibres, caused an intertwining mass. This study further found by electrophysiological recordings that the neuromas presented uncharacteristic features and the stump showed nerve fibres displaying regular and irregular discharge patterns.

2.4.3 Pain associated with infra-red trimming

While infra-red technology is an advanced method of beak trimming, there are still welfare concerns that this technique can result in short and long-term pain (Cheng, 2006). In some birds just after IRBT treatment a short-lasting neural discharge was recorded from the major peripheral nerve of the lower beak (Cheng, 2006). Studies have reported that IRBT has fewer adverse effects than HB trimming because the elimination of open wounds, further infection and inflammation that may lead to pain, (Gentle, 2011; Marchant-Forde *et al*, 2008, Honaker and Ruszler, 2004). This technique has shown that beaks trimmed were more uniform in length and showed fewer problems of cracks, blisters and irregular regrowth (Carruthers *et al,* 2012; Marchant-Forde *et al,* 2008).

Work by McKeegan and Philbey (2012), studied long-term effects of IRBT on laying hens over a period examining beak nerve function and changes to beak anatomy. Mechanoreceptors, thermoreceptors and nociceptors were investigated on IRBT birds and intact birds (controls).

At 10, 30, and 50 weeks both treatments showed sensory nerve sensation and sensitivity to thermal and mechanical stimuli to the lower beak. There was no effect on nociceptive function for either treatment or age. Further microscopic work on the beak tip highlighted evidence of healing to the extent of bone remodelling. At 4 weeks of age IRBT birds showed nerve regeneration and new populations of mechanoreceptors. However, older birds did show a loss of nerve supply and scarring. As with this study and others, it has been witnessed that less neuroma formation occurs with IRBT in laying hens and in broiler breeder chicks (Morrissey *et al*, 2016, Gentle and McKeegan, 2007). McKeegan and Philbey (2012) concluded that IRBT does not cause chronic pain or inhibited sensory function. It also appears that IRBT is effective in preventing beak regrowth maybe because the heat source penetrates down into the corneum-generating basal tissue and produces less inflammation after trimming, resulting in a shortened beak after the treatment.

2.5 Policy and Legislation

The poultry industry has become reliant on BT, even though IP is still evident in beak-trimmed flocks. Traditionally BT was conducted by the HB method within the UK but only IRBT is now permitted following recommendations by Farm Animal Welfare Council, now committee (FAWC). Yet, the use of hot blade trimmers remains in Spain, Italy, Portugal, France, Greece and Eastern Europe (BTAG review, 2015). In the EU the 1999 Hens Directive (99/74/EC) considers BT a mutilation and it is only permitted on chicks no older than 10 days old and as a preventative measure should an emergency outbreak of IP and cannibalism occur in older birds, and after all attempts of veterinary advice and management strategies have failed (RSPCA 2013). Scandinavian countries such as Sweden, Norway, Switzerland and Finland already have a legislative ban on all forms of beak trimming (Riber and Hinrichsen, 2017; Spoolder *et al*, 2016, Van Horne and Achterbosch 2008). Denmark doesn't currently have a ban enforced by law, but the Danish Egg Association has already omitted beak trimming in all its laying hen flocks; caged, barn and free-range (Riber and Hinrichsen, 2017). More recently in 2017, Germany banned BT and the Netherlands has a ban due to come into force from September 2018, with the possibility of the UK following the trend in the near future (Riber and Hinrichsen, 2017, BTAG, 2015, Poultry World, 2013). Currently, BT is still widely used in all housing systems within the UK.

In 2002, The Beak Trimming Action Group (BTAG) was formed in response to proposed legislation to implement a ban on routine beak trimming, which was originally scheduled to take place in the UK in 2011. BTAG worked closely together sharing knowledge and expertise with representatives from the poultry industry, veterinary and scientific specialists, animal welfare NGO's (including Farm Animal Welfare Council, (FAWC), Compassion in World Farming (CIWF) and retailers). In 2011 the ban was deferred by recommendation of FAWC as evidence highlighted that the control of IP was not adequate on commercial farms. During new regulations (the Mutilations (Permitted Procedures) (England) (Amendment) Regulations 2010) made HB trimming illegal. However, IRBT was still permitted on birds under 10 days old and as a preventative measure on older birds. Again, the same ruling applied to other areas of the British Isles; Scotland, Wales and Northern Ireland (BTAG, 2015). In the UK, a potential ban of beak trimming was proposed for 2016 in line with the requirements of EU legislation (Directive 99/74/EC), but before this was implemented further research was commissioned.

The use of evidence-based research to inform legislative decisions is relatively uncommon, but in 2012 in the UK, Defra commissioned the University of Bristol to conduct a 3-year study measuring the effectiveness of tailor-made management strategies on intact (non-beak trimmed) cage free flocks throughout the rearing period and up to depopulation, generally at 72 weeks of age. Twenty flocks were recruited, all free-range apart from two barn flocks. Each flock received advice and specialised management strategies to help reduce the risk of IP and was given enrichments such as nets filled with straw, pecking blocks, absorbent wood pellets used to help with maintaining litter quality, enhancements for the range (artificial shelters, tree planting) and additional stockmanship approaches. The results emphasised that no problems of IP were witnessed on any of the rear farms. However, later when the birds were in the laying sheds problems did result in high mortality losses and severe IP outbreaks in two of the intact flocks in comparison to flocks of beak trimmed birds. It was concluded in the final report that management strategies did reduce IP on farms that had previously kept intact birds. Nevertheless, the transition from BT to intact was still highly risky even if management strategies were employed.

A similar trial was conducted by Scotland Rural College (SRUC) observing birds in furnished cages. The project assessed two genotypes: the Hyline Brown and Lohmann Traditional. Both breeds had treatment and control flocks of intact beaks and beak trimmed birds. There were sixty-four cages of 80 hens in each cage with some flocks having the standard enrichment and other flocks having additional enrichment added to the enriched cages. The overall results from IP mortality showed 1.02% in non-beak trimmed birds; 0.35% in beak trimmed. The additional enrichment had no effect on IP in relation to mortality losses (BTAG, 2015). From both these studies BTAG came to the decision that a ban on routine beak trimming may not yet be feasible and would be to the detriment of hen welfare (BTAG, 2015). With this evidence the agricultural minister decided that a ban would not take place but indicated that he expected the industry to continue to work to reduce problems of IP such that a ban might be possible at some future date.

2.6 Beak Morphology

A potential method for controlling IP is to explore phenotypic variation in beak shape and physical characteristics in laying hens. Currently, there is limited research in poultry and the possible manipulation of beak characteristics is only recently being explored. If beak morphology is to be manipulated it must first be measurable. Previous studies have measured beak characteristics of length, depth and circumference using callipers and this method has proved to be successful for measuring beaks in chickens (Van de Weerd, 2005, Elson, 2004). These univariate measures (length, width and depth) have been used to calculate beak size and shape but these methods did not assess shape independently of size (Dalton *et al,* 2015, Foster *et al,* 2007). These studies did not explore and measure beak curvature because of the complexity (Van de Weerd, 2005, 2004). Previous work by Soons *et al*, (2010) have shown evidence of diversity in beak length, depth and strength in Darwin finches. So, in theory, these findings suggest that beak diversity would be seen in chickens and selection for beak shape may be possible.

Landmark-based geometric morphometrics is a computer analysis which detects changes in shape by visualising landmarks allowing to join up the points giving the capacity to draw diagrams of morphological differences (Webster and Sheets, 2001). The technique has recently been used to define shape variability which does not change after scaling. This method has been used successfully for several species from the beaks of Darwin's finches and more recently chickens and turkeys (Dalton *et al*, 2015, Osborn, 2014). Exploring the use of curvature as a measurement of beak shape, Foster *et al*, (2007) found differences in species of Darwin's finches that highlighted variation in dimensions of the beak, the position of both the upper and lower mandibles and curvature. In measuring curvature of chicken's beaks, it is important to consider both beak length and the sharpness of the beak tip (hook), two important factors that have the capacity to cause pecking damage.

Osborn (MSc thesis, 2014 unpublished research) investigated individual variation in beak shape of free-range end of lay hens and by using geometric techniques detected significant variation in curvature between beaks. It was reported the range of coefficients of variation for the curvatures were 30.1-34.8% and the geometric method of analysing photographs showed a more accurate result in comparison to direct calliper measurements. Thus, a recent study has contradictory findings suggesting there was no statistical difference between breed variation in two breeds; Lohmann Brown (LB) and Hyline Brown (HBR) in beak shape variation of intact beak and beak trimmed laying hens at 64 weeks focusing on upper and lower mandible, beak length to include overhang and inner angle of the beak. The outcome showed that intact birds had a longer upper mandible and beak overhang and the trimmed birds had longer lower mandibles, but this would be as expected (Morrissey *et al*, 2016).

Recent work in turkeys (Dalton *et al,*2015) measured beak shape by landmarking 596 untrimmed turkeys, finding 85.02% of beak shape variation was in the depth of the upper mandible. It was evident that there was a distinction at the beak base as well variability in the point of curvature of the upper beak. Beak size was not highly significant with 1.96% of total shape variation. Further work by Dalton, *et al,* (2017) emphasised that beak shape variation was seen at 6 weeks and 18.5 weeks of age in turkeys. Further analysis of male and female beak shape was also significantly different ($P < 0.0001$) female turkeys having a wider upper mandible, where males were narrow. The dorsal was long with a curved beak tip in females but dorsal was short with pointed beak tips in male turkeys.

Measuring of beak shape has recently been achieved by a device that measures the excess of the upper beak, which is then automatically saved in a database (Icken, *et al*, 2017). A recent study investigated beak shape in four brown eggs lines of Lohmann Browns (LB's) for three generations. Findings concluded that there was not much difference in the upper beak measurements at 23 or 48 weeks for three lines suggesting it was determined by beak growth and abrasive furnishings. Although one line did show to have a shorter beak at both ages. A further study of four lines of brown eggs lines LB's and white egg lines Lohmann Selective Leghorn (LSL) of 3000 birds per line at 30 weeks in the LB's showed there was a marginal difference between the three lines, but one line again showed to have a slightly shorter beak. However, results between the LB's and LSL highlighted there was a difference in both the upper and lower beak measurements with the LSL showing to have a much shorter beak 0.4mm in comparison to the LB birds 0.8mm. This study also concluded that birds which had shorter beaks had better feather cover and lower mortality indicating there is potential to select genotypes with shorter beaks.

Icken *et al,* (2017), Dalton (2015, 2017), and Osborn (2014) data suggests there in variation between two genotypes of chickens, individuals of turkeys and chickens within breeds. However, the significant question is, is beak shape variation down to genetics or in fact predisposed by the environment or is it the combination of the two? If variation in shape is revealed by genetics then future genetic applications could be selected for genotypes which show to have blunter, less damaging beaks.

2.7 Management strategies to reduce the risk of Injurious pecking at lay

There has been a driving force from industry to encourage poultry farmers to improve bird welfare on their laying farms. This has been influenced by consumer opinion and many of the assurance schemes such as RSPCA Assured and British Lion Code. Over the years tailored management strategies that include enrichment devices have been shown to reduce the risk of IP on the laying farm (Lambton, *et al,* 2013). Birds can be shown to be fearful, lack cognitive ability and be attracted to feathers in barren environments with limited enrichment and foraging opportunities (Jones, *et al,* 2000). One approach is to provide birds with alternative substrates with the aim of satisfying their motivation to peck at objects as part of their need to forage. Enrichment needs to satisfy the bird's behavioural needs; therefore, enrichment devices need to be attractive (Jones and Carmichael, 1999). They also need to retain interest to the birds and have the advantage of being low cost, easily accessible and not labour intensive for the farmer.

Considerable research has investigated the use of environmental enrichment for various poultry species. Plastic toys given to hens in conventional (unfurnished) cages not only reduced aggressive behaviour but also improved egg production and a decrease in mortality was seen (Gvaryahu, *et al,* 1993). Sherwin, *et al,* (1999) observed a reduction in IP in turkeys when given chain and ropes. Greater foraging opportunities in the laying house is known to be beneficial for bird welfare. Dixon *et al,* (2010) found that straw reduced IP in laying hens and polystyrene blocks, sand or wood shavings have also been successful (Huber-Eicher and Wechsler, 1997, 1998). Studies have emphasised that forms of enrichment that laying hens can manipulate satisfies their foraging motivation (Dixon *et al*, 2010; Huber-Eicher & Wechsler 1998, Blokhuis, 1989). String has proven to be beneficial (McAdie *et al,* 2005) with white or yellow string seemingly preferred over blue or orange (Morrissey *et al*, 2016, Jones *et al,* 1998). We know that white string is popular to chickens of any age, especially if introduced at young age (Jones *et al,* 1998) and that it retains interest over a long period of time and provides an effective strategy for reducing IP.

2.7.1 Management strategies to reduce the risk of Injurious pecking at rear

Studies suggest that providing pecking material for chicks or pullets could be a useful way of directing their pecking behaviour to harmless substrates (Lambton *et al, 2*013). Yet it has been recognised that many enrichment devices remain unnoticed by many younger birds (Jones, 2001) and studies have shown rearing chicks in a barren environment can potentially cause lethargy, fear, and extreme boredom, abnormal and unwanted behaviour (Jones, 2001, 2002). This lack of exploratory behaviour has been witnessed in broiler houses where broiler chicks have barren, unstimulating environments (Newbury, 1999) and when given the opportunity will seek out novel enrichment daily (Newberry, 1999). Studies by Huber-Eicher and Wechsler (1998) found straw and polystyrene blocks effective promoting in foraging behaviour along with a reduction in IP in laying hen chicks. String likewise showed positive results with young chicks (Jones *et al*, 2000). A study by Jones *et al,* (2002) has shown that laying strains of chicks such as ISA Browns and Lohmann Brown preferred pecking at string over chains and beads. The results of the study also found that the birds preferred playing with string significantly more than their conspecifics whose feathers had been trimmed to see if a likely event of IP would occur. Furthermore, the provision of string from day one sustained interest until the birds reached 17 weeks of age (Jones *et al,* 2002). Many supports that enrichment should be provided at a day old or before 10 days (Huber-Eicher and Wechsler, 1997). However, adult hen behaviour is flexible, and it is considered that it can be motivated by supplementary resources to promote foraging opportunities (Nicol, *et al,* 2001). Given the strong need to reduce IP at rear no such studies have investigated the effect of an enrichment that additionally has potential to aid beak bluntness.

2.8 Abrasive Beak Blunting

An important factor that may influence variation in chicken beaks could be the environment suggesting that abrasive beak blunting might be an effective technique. However, there seems to be limited research investigating beak blunting on laying hen and rearing farms regarding abrasive enrichment objects. Beak blunting is a method by which the bird blunts its own beak tip on abrasive material (Fiks-van Niekerk and Elson 2004). A study by Fiks-van Niekerk and Elson (2004) evaluated the effectiveness of beak abrasion as an alternative to BT in laying hens in caged and non-caged systems both during rear and in the laying house. The study put an abrasive material inside a feeding trough at rear (from 6 weeks) and lay (from 18 weeks) and the assessment of beak was measured by length at a four-week interval. Beak measurements were taken by vernier callipers from the top of the beak, level with the front of the nares, to the tip of the beak. Additionally, one side of the beak to the tip was measured as well as the overhang of the upper mandible.

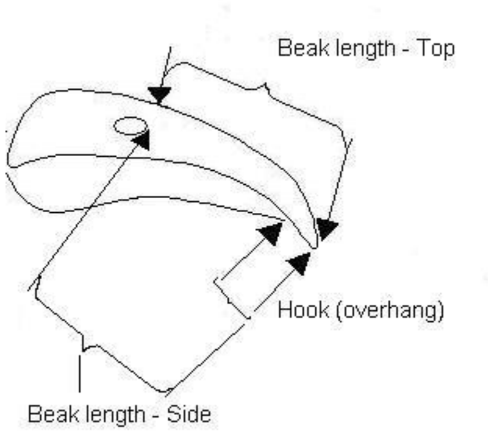


Figure 1. Diagram of top and hook beak measurements (Fiks-van Niekerk and Elson 2004).

During week 6 and 12, the intact birds with no abrasive treatment did show a significantly longer top beak measurement than birds having access to the abrasive material. It was considered that the beak may have shortened due to the newness of the abrasive material and with the addition of the chicks with very soft beaks. The study confirmed it was problematic trying to standardise and measure such small beaks. Overall the study found that placing abrasive materials inside a feeding trough at rear and lay did shorten beaks by 1-2mm, but these were more effective at shortening beaks during the laying period, this maybe because the young pullet's beaks are continuously growing. However, placing the abrasive material on the chain feeder was not so effective. Furthermore, it highlighted that beak blunting did not seem to affect birds performing beak related behaviours, although it was concluded that this area needed more investigation as hook measurements proved not to be accurate by calliper measurements.

A recent paper by Morrissey *et al*, (2016) explored the effect of strain and extra enrichment on intact beak hens in furnished cages. Hens (Lohmann Brown Classic (L) and Hyline Brown (H) were assigned treatments from 16 weeks to 71 weeks and data collected every four weeks. The study investigated an array of environment enrichments from polypropylene ropes, beak blunting boards and pecking mats. The blunting boards were made of an abrasive paste painted onto a Perspex backing and pecking mats contained a mixture of compressed wood chips and biodegradable glue on a plastic mesh. Both these enrichments were hung vertically to the front of the cages. The results showed that the extra enrichment showed no effect on the beak length or beak sharpness on the upper mandible. Furthermore, there was no significant effect of breed on any of the beak measurements recorded. Even though the intact birds performed more damage to the ropes and mats, the blunting boards were not well used. Hence there was no real change in beak length. Morrissey *et al,* (2017) recently reported that cuttlebone did show a positive outcome by reducing beak length by shortening the upper mandible, but as suggested by the author they may be difficult to apply commercially as they tend to be brittle and worn away quickly. Despite this, some of the enrichments were well used in intact and beak trimmed birds so there may be an application of designing improved or more effective abrasive enrichment tools for caged hens.

It has been suggested that enrichment devices such as hard pecking blocks could blunt the bird's beaks naturally through normal levels of wear but currently there is no published evidence regarding the effectiveness of hard blocks. Pettersson *et al,* (2017) has however recently reported that such hard blocks can be well-used. These authors investigated the effect of commercially available pecking pans (Vencomatic, Yorkshire, UK) containing a particulate pecking block intending to promote pecking activity on fourteen laying farms throughout the UK over a 2-year period. Pecking pans were placed within the two weeks of birds being housed and scan and focus observation recorded at both 25 and 40 weeks. Results from the scan observation showed pecking activity and perching on the pan did not change significantly over the duration from 25 – 40 weeks and again this was observed with the focal sampling. However, the average number of birds within 1 m of the pecking pan significantly decreased from 25 to 40 weeks and the number of pecking bouts decreased significantly over time. Perching activity on top of the pan increased with birds perching for longer and more often when birds reached 40 weeks. This perching activity may be a factor, birds blocking access to the block and contaminating it with faeces may be why birds lost interest. The loss of interest in soiled enrichment has been seen in pigs (Grandin, 1989). The recent study by Pettersson *et al,* (2017) has indicated that retaining interest and novelty in enrichment devices is somewhat difficult to achieve.

Recently a study by Zepp *et al*, (2018) investigates stocking density (SD) and enrichment in laying hen chicks to reduce the occurrence of IP. Enrichments comprised of pecking stones (VILPLith), pecking blocks (PICKBLOCK) and Lucerne bales (Lucerne and compressed grass). Enrichments were placed from day 36 to day 120. Behaviour observation of enrichment use, GFP, SFP and AP was video recorded over several days. Overall the Lucerne bales concluded to be most popular of the 3 enrichments having the highest rates of pecking activity- 3 minutes, then followed by pecking stones and then pecking blocks. There was no effect on age for any of the enrichments for any of the days neither was there a significance on feather pecking. AP behaviour was hardly witnessed in any of the flocks. Yet there was a significant reduction in GFP and SFP in the groups which had enrichment present. It was also reported that GSP, SFP and AP appeared to decrease at the end of 2 successive rearing period.

Further work by Bain (BSc thesis, unpublished 2013) found when introducing pecking blocks, consisting primarily of compressed molasses, limestone and grain, at 30 weeks of age, the birds demonstrated interaction with the pecking blocks during the first week and by week two 80% of birds were engaged in increased additional foraging behaviour. A further study by Weeks *et al*, (2011) of 90 commercial flocks demonstrated that commercial hens pecked at aerated breeze blocks. This was one of the most effective additions to the birds' housing with the potential to blunt the sharp beaks of the birds, in effect, naturally beak tipping them. According to van der Linde (2016) cited in Icken (2017) turkeys which had continuous access to pecking stones did show that they did blunt the beaks. After 6 months of access around 80% of birds resembled their conspecific that had been beak trimmed. While most of these studies on commercial farms investigated the use of these devices to reduce levels of IP only a few have measured their effect on beak bluntness. Thus, investigating this is a primary objective of this thesis.

3. Aims and hypotheses of study

The aims of the current study in pullets at rear are:

1) To see whether provision of abrasive material supplied in pecking pans reduces beak sharpness in intact and beak-trimmed birds.
   It is hypothesised that birds with pecking pans will have blunter beaks.

2) To monitor use of pecking pans throughout the rearing period.
   It is hypothesised that birds will use the pecking pan throughout rear.

3) To determine whether the provision of pecking pans reduces injurious pecking.
   It is hypothesised that birds with the pecking pans will have reduced levels of injurious pecking.

Secondary Aims

4) To monitor beak growth with age during rear.

5) To consider genotype variation by using different breeds as part of the experimental design.

4. Materials and Methods

4.1 Ethical Approval

This study had ethical approval from the University of Bristol ethics committee. Reference UIN UB/15/053.

4.2.1 Experimental Design

Commercial rearing farms were used in this study within the UK between September 2015 and December 2016. Throughout the study some sheds were used more than once as more than one flock passed through them. Half of the 16 flocks were beak trimmed by infra-red (IRBT) at a day old at the hatchery and the other half were intact beak flocks. Each flock was visited three times throughout the rearing period. The first visit was at 6-7 weeks of age, second visit at 10-11 weeks and final visit at 14-15 weeks of age. Eight of these flocks were supplied with Bristol pecking pan (treatment flocks) and half were controls. The experimental design consisted of 4 intact treatment, 4 intact control, 4 trimmed treatment, 4 trimmed control flocks.

4.2.2 Animals and Housing

The sixteen flocks that were available for this study included the following breeds: British Blacktail (n=8), Lohmann Brown (n=6) and Bovans brown (n=2). Flocks size ranged from 3,300 – 11,000 and the average flock size was 6,843 **(See Table 1 for flock information)**. All flocks were reared in loose house systems with wood shavings or shredded paper as the floor substrate. Most of flocks had perches except for two which had slatted system. Feeding systems were chain feeders for all flocks. Five flocks of the study were reared on organic feed and the others were reared on commercial standard ration. No flocks had access to the outside.

Table 1: Genotypes, Flock Sizes, Beak Status and experimental groups.

Flock Number	Genotype	Flock Size	Intact	Infrared Beak trimmed	Pecking pans (1 per 500 birds)	Control without pecking pans
1	British Blacktail	10000		X		X
2	British Blacktail	10000	X			X
3	Lohmann Brown (organic feed)	9000	X		X	
4	Lohmann Brown	11000		X	X	
5	Bovans Brown	9000		X	X	
6	Bovans Brown	8000		X		X
7	Lohmann Brown (organic feed)	3600	X			X
8	British Blacktail	3600		X	X	
9	Lohmann Brown	10000		X		X
10	British Blacktail	8000		X	X	
11	Lohmann Brown (organic feed)	6400	X		X	
12	British Blacktail	6500	X		X	
13	British Blacktail (organic feed)	4100	X			X
14	Lohmann Brown (organic feed)	3400		X		X
15	British Blacktail	3300	X		X	
16	British Blacktail	3600	X			X

4.3 Pecking Pan Resource

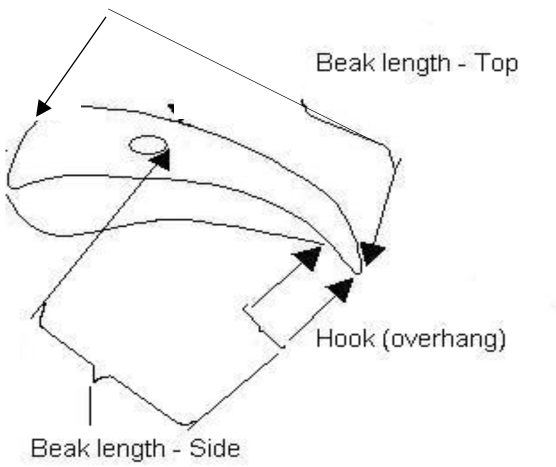
Treatment flocks had access to pecking pans which were supplied by Vencomatic UK. These consisted of a green plastic pan feeder, with a detachable grey base. The pan contained a hard block consisting of materials such as sand, cement and oyster shell for the birds to peck **(see Fig 2)**. Each treatment flock was given one pecking pan per 500 birds evenly positioned and distributed on the litter area throughout the rearing house. The number of pecking pans were using the method of FeatherWel, (2013). The pecking pan was placed the day before the first observations commenced to allow the birds to acclimatise to them and they remained for the rest of the rearing period.

Figure 2: Pecking Pan

4.4 Beak Measurements

A sample of the birds (45 per visit at 6/7wks, 10/11weeks and 14/15 weeks) was selected from different areas of the rearing house for beak measurement.

Birds were randomly selected by counting three birds to the right of a bird first focused upon. Birds were caught in the afternoon after behavioural observations took place, so the birds' behaviour would not be influenced by catching and handling of the birds. Birds were gently restrained by one person and wrapped in a disposable cloth to contain their wings, so they could be easily handled. The top of the right leg of each bird was given a black dot with a marker pen to ensure that these birds would not be recaptured throughout the study. Direct measurements were taken first, and beak characteristic and length were measured using Vernier callipers, method slightly adjusted from (Van de Weerd, 2005). Three different beak measurements were taken on the right side from the point on top of the beak, level with the front of the nares to the tip of the beak and measurements of the overhang (if any) of the upper mandible over the lower mandible of a closed beak. Each measurement was repeated three times in succession to provide a mean length with 0.5mm accuracy.



Photograph adapted from: Fiks van Niekerk and Elson, (2005) Van de Weerd, (2005)

Figure 2.1: Side view diagram of a beak to indicate where the three beak measurements were taken using Vernier calliper.

Figure 2.2: Measuring side length of beak using Vernier callipers.

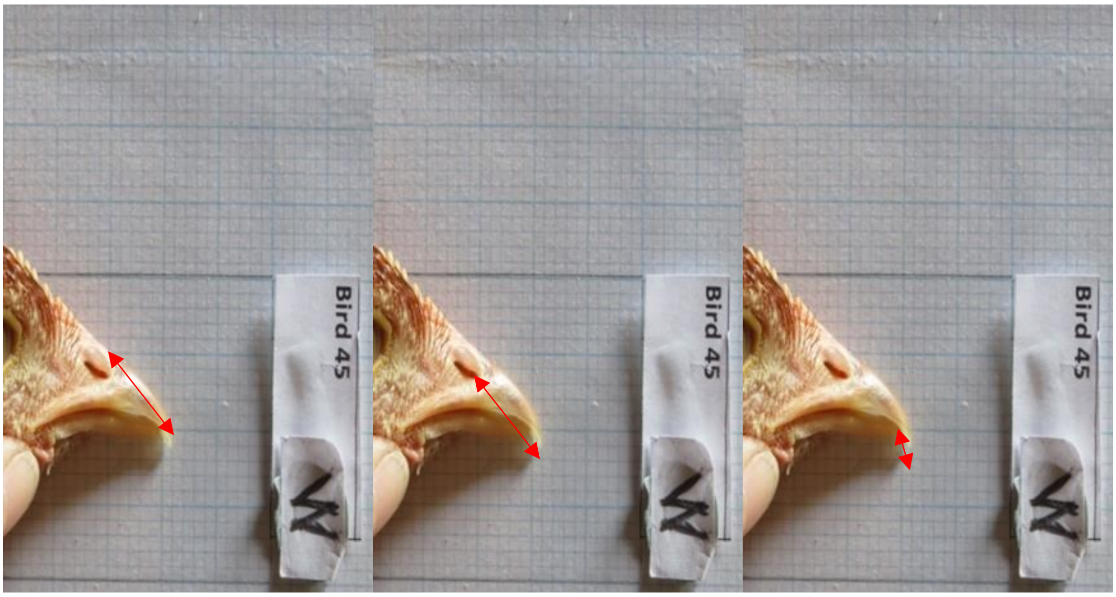


Figure 2.3 The red line on each image indicates the measurement that was taken on live birds, from left to right, top length, side length and hook length.

4.5 Beak Shape and variation

After direct calliper measurements were taken photographic images of each bird's beak were made. Birds were still wrapped up for ease of handling. The photography equipment was set-up in the small office area, adjoining the rearing shed. A Canon SLR camera was used for all digital images and was mounted on a tripod. The tripod was positioned on a table with the camera lens facing downwards and remained in the same position and height throughout the study. Right lateral images were taken of each beak with a 10 x 10mm gridded background for scaling. The photographic images of chicken's beaks will be used for further work in developing an application for image processing and classification of beak sharpness in pullets.

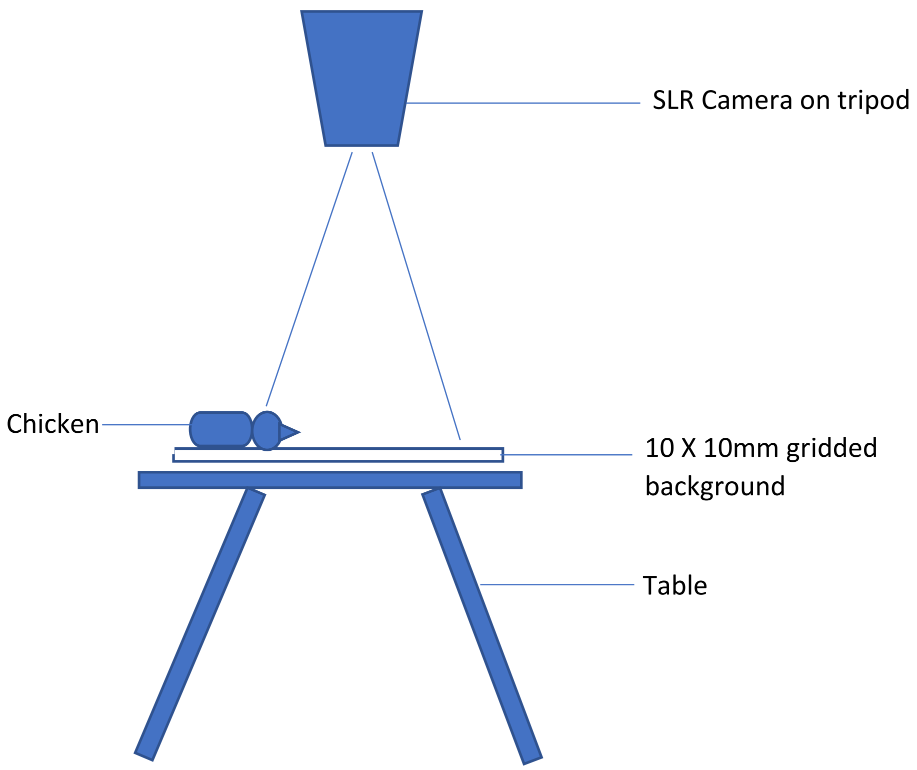


Figure 2.4: Experimental set up of the photography equipment on farm.

4.6 Behavioural Observations

4.6.1 Injurious Pecking Behavioural Observations

Observations of pecking behaviour were recorded at each visit between the hours of 08.30 – 12.00 and generally matched for time of day across all visits. Observations were recorded on paper and then entered in an Excel spreadsheet. An area of approximately 2 m^2 was chosen and 5 minutes observations of all instances of IP and aggressive behaviour during the same observation were recorded in 9 areas of the house, (total of 45 minutes) to give a representative sample. A 2-minute habituation period allowing the birds to become accustomed to the presence of the observer was used and observations were taken at a 1 metre distance to minimise bird disturbance. The number of birds was counted in the observation area before and after the observation to calculate the average number during each observation period. Observations included: bouts of gentle feather pecking (GFP). A bout was defined as continuous pecking until another behaviour was performed or the behaviour stopped for a 5 second gap (Kjaer and Sorensen, 2002). Individual incidents of severe injurious pecking (SFP), instances of vent pecking (VP), cannibalistic pecking (CB) and aggressive pecking (AP) were recorded ref Table 2.

Table: 2 Definitions of observed injurious and aggressive behaviour.

Behaviour	Definition
GFP	Soft gentle feather pecking, without pulling and removal of feathers
SFP	To peck or pull out the feathers of other birds with force
AG	Forceful pecking directed at the head and neck region
VP	Pecking directly at the vent area
CB	Pecking at exposed skin creating wounds, leading to cannibalistic pecking

4.6.2 Pecking Pan Interaction Observations

Focal sampling techniques were used to record usage of the pecking pan in treatment flocks. To encourage and reassure the birds of the novel object 2 handfuls of organic mixed corn was sprinkled into each of the pecking pans the afternoon before data collection took place on the first visit. Recordings were randomly taken on half of the pecking pans within 1 square metre to minimise bird disturbance. A 2-minute habitation period allowed the birds to become accustomed to the presence of the observer. Two individual birds were counted from the start and the number of pecks at the pecking pan were recorded up to 2 minutes. If the bird discontinued to peck and leave the area the observation ended, and the time was recorded.

4.7 Plumage Scoring

Plumage condition was assessed using the method of Bright *et a*l, (2006) at 14/15 weeks (final visit) at the end of the rearing period. This time point was decided as young chicks and pullets go through many moults throughout rear. 108 birds (per flock) were visually scored in 9 areas of the house on the litter area. Birds at this point were not handled and randomly selected by counting three birds to the right of the first bird to be focused upon. Feather cover was assessed and scored for 5 areas of the body - neck, back, tail, rump and wings. A 5-point scale was used (0 = No damage to 4 = Severe damage to skin and very large injured areas (>10cm^2 traumatised). A more in-depth inspection was done by picking up the 45 birds during their final beak measurements at the final visit and giving them a thorough examination (using the same 5-point scale).

4.8 Trials for measuring pecking pan usage

Pecking pans were assessed each visit for minimum, medium and maximum wear alongside additional photographs of the pecking pans were taken. However, it proved difficult to assess wear and compare or weigh the pecking substrate throughout the 3 visits. This was owing to the substrate not being standardised in each pecking pan and from time to time the pecking pan itself would be filled with hen excrement. So, this part of the trial was abandoned from the study.

4.9 Statistical Analysis

The data collected from the study were evaluated for significant relationships using statistical tests in IBM SPSS version 23. Normality tests were performed and none of the data were normally distributed even after transformation therefore non-parametric statistical analyses were used.

The mean of the 3 replicate measurements of beak top, side and hook length for each of the 45 birds sampled per flock at each visit was calculated and used for the main analyses. Mann-Whitney U tests were used to compare TOP, SIDE and HOOK lengths between British Blacktails (BBT), Lohmann Browns (LB) and Bovans Brown (BB) for the three visits. Further Mann-Whitney U tests were conducted to explore beak characteristics between intact and beak trimmed birds and pecking pan presence. A Bonferroni adjustment was used to reduce chance of type (1) errors because independent tests were being performed simultaneously on a single data set [15 Tests 0.05 / 15 = 0.003].

Mann-Whitney tests were used to compare mean pecking activity between intact flocks and beak trimmed flocks with age. A Kruskal-Wallis H test was used to investigate pecking pan activity in both intact and beak trimmed birds over the 3 visits. Furthermore, a Kruskal -Wallis H test was used to explore breed effect in correlation with age.

For each flock the mean value of the 9 observations of feather pecking behaviour was calculated for visits 1, 2 and 3. A Bonferroni adjustment was used to reduce chance of type (1) errors because independent tests were being performed simultaneously on a single data set [15 Tests 0.05 / 15 = 0.003].

Mann-Whitney U tests were used to compare intact and beak trimmed birds with or without a pecking pan in relation to age. Further Mann-Whitney tests were used to investigate the breed and age effect between intact and beak trimmed flocks.

Additionally, a Kruskal-Wallis H test investigated breed effect and age effect over the 3 visits. For each flock, the mean plumage score at the final visit was calculated. Mann-Whitney U tests were used to compare intact and beak trimmed flocks. A further Mann-Whitney U test compared plumage damage for flocks with or with the pecking pan. A Kruskal-Wallis H test explored breed influence on plumage damage. Similar statistical tests were performed on the 45 birds/flock which were plumage scored during handling for beak measurements.

5. Results

5.1 The effect on beak characteristics in intact and beak trimmed birds with/without pans

The data was analysed based on beak status. There was a significant effect on side mean beak length being shorter in all birds with a pecking pan present, irrespective of beak trimming. A Mann-Whitney U test revealed at the first visit when the birds were 6/7 weeks a significant difference was seen in side mean length being shorter in birds with a pecking pan ($U = 53.60$, with pecking pan, $n = 360$, $Md = 9.83$, without pecking pan, $n = 330$, $Md = 10.13$, $p<0.001$). Although, there was no significance in hook or top length.

The second visit at 10 – 11 weeks again showed a highly significant difference with side mean length being shorter in the birds presented with a pecking pan ($U = 46.04$, with pecking pan, $n = 360$, $Md = 12.84$, without pecking pan, $n = 330$, $Md = 13.97$, $p<0.001$). A significant difference was also seen of the top length measurement which was shorter with birds having a pecking pan ($U = 48.49$, with pecking pan, $n = 360$, $Md = 15.56$, without pecking pan, $n = 330$, $Md = 16.46$, $p<0.001$). By the third visit, birds aged 14-15 week no significance difference in any of three measurements was seen.

The graph below **(see Figures 5.1**) illustrate variation with pans v no pans, visits/age for beak measurements in intact beak and beak-trimmed birds.

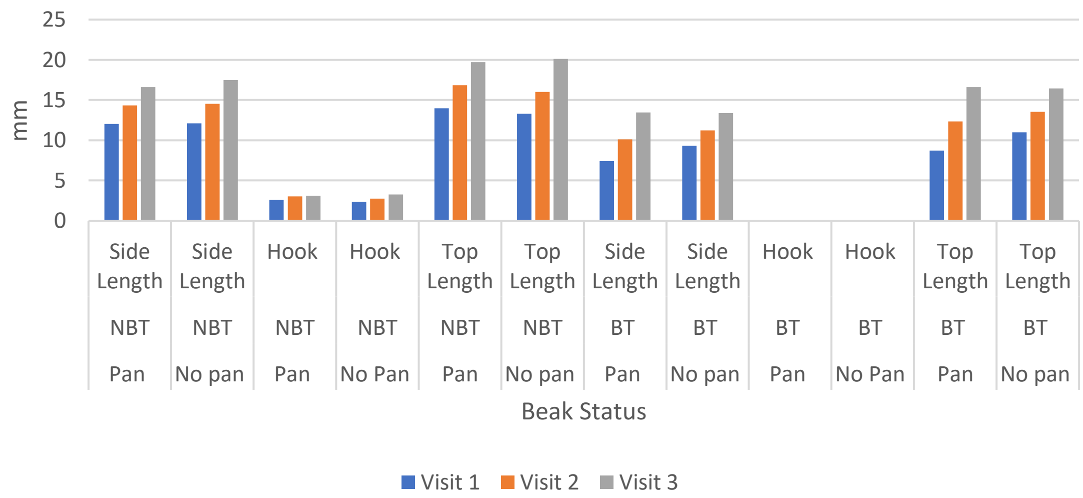


Figure 5.1: Beak measurements for intact and beak trimmed birds verses pans or no pans

5.2 Breed effect on beak characteristics in intact birds with or without pecking pans.

Mann-Whitney U test for breed effect in intact flock was strongly significant between the two breeds BBT's and LB's. Results presented that there was no significance in any of the three mean flock measurements for the BBT's at the first visit at 6-7 weeks with or without a pecking pan. However, the LB flocks did show a significant difference in all three measurements during the first visit at 6-7 weeks of age. LB's had significantly longer beak side length in flocks which had the pecking pan present ($U = 4.00$ pecking pan present, $n = 90$, $Md = 10.40$, without pecking pan, $n = 45$, $Md = 6.45$, $p<0.001$), longer hook length in flocks which had the pecking pan present ($U = 4.00$, with pecking pan, $n = 90$, $Md = 2.84$, without pecking pan, $n = 45$, $Md = 1.26$, $p<0.001$), longer top length in flocks which had the pecking pan present ($U = 4.00$, with pecking pan, $n = 90$, $Md = 11.91$, without pecking pan, $n = 45$, $Md = 7.30$, $p<0.001$).

During the second visits when birds were aged around 10-11 weeks, the LB flocks demonstrated a shorter mean length in all the three measurements when a pecking pan was present. Mann- Whitney test showed shorter beak side length, ($U = 1.23$ pecking pan present, $n = 90$, $Md = 12.42$ without pecking pan, $n = 45$, $Md = 15.40$, $p<0.001$), shorter hook length in flocks which had the pecking pan present ($U = 1.23$, with pecking pan, $n = 90$, $Md = 3.10$, without pecking pan, $n = 45$, $Md = 2.26$, $p<0.001$), and shorter top length in flocks which had the pecking pan present ($U = 1.23$ with pecking pan, $n = 90$, $Md = 14.24$, without pecking pan, $n = 45$, $Md = 18.05$ $p<0.001$).

The BBT's again showed no significance in mean side and top length but did show a significant difference in a longer hook length in flocks which had the pecking pan ($U = 6.97$ pecking pan present, $n = 90$, $Md = 3.09$ without pecking pan, $n = 120$, $Md = 2.98$, $p<0.001$).

By 14-15 weeks of age, both breeds (BBT's and LB's) showed no significant difference in any of the three measurements if a pecking pan was present or not.

5.2.1 Breed effect on beak characteristics in beaked trimmed birds with or without pecking pans.

There was a strong significant difference in two of the breeds at 6-7 weeks of age. The BBT's and the LB's birds mean side length was longer without access to the pecking pans. BBT's side length (U = 8.35, without pecking pan, n = 90, Md = 9.50, with pecking pan, n = 90, Md = 6.72, p<0.002). LB's side length, (U = 47.00, without pecking pan, n = 90, Md = 10.04, with pecking pan, n = 45, Md = 7.32 p<0.001). However, there was no difference found comparing BB bird beak measurements with other breeds.

The BBT's without access to pecking pans had significantly longer hook length than the other two breeds. BBT hook length (U = 8.35, without pecking pan, n = 30, Md = 0.00, with pecking pan, n= 90, Md = 0.00, p<0.001). LB birds presented a longer top measurement without the pecking pan (U = 47.00, without pan, n = 90, Md = 12.10, with pecking pan, n = 45, Md = 8.10, p<0.001). This result was not witnessed in the other two breeds.

The second visit at 10-11weeks of age revealed a difference in beak measurements in the three breeds. At this time point, the LB flocks again had a longer mean side and top length. Side length was longer in birds without a pecking pan (U= 0.00, without pecking pan, n = 90, Md = 8.33, with pecking pan, n=45, Md = 8.33, p<0.001). Mean top length, (U = 0.00, without pecking pan, n = 90, Md = 9.61, with pecking pan, n=45, Md = 9.62, p<0.001). No significance was seen in the other two breeds. Hook mean length differed between the three beak trimmed breeds. The BBT's flocks showed a significant result with birds having a longer hook length with birds not having pecking pans (U = 1.01, without pecking pan, n = 30, Md = 0.00, with pecking pan, n = 90, Md = 0.00, p<0.001). This was not significant for the LB and BB flocks. By visit 3, 14-15 weeks of age, all measurements were not significant for all the three breeds; BBT's, LB's and the BB's with or without the pecking pan.

The graph below **(see Figures 5.2**) illustrate variation with pans v no pans, visits/age/breed and three beak lengths measured for intact beak and beak-trimmed birds.

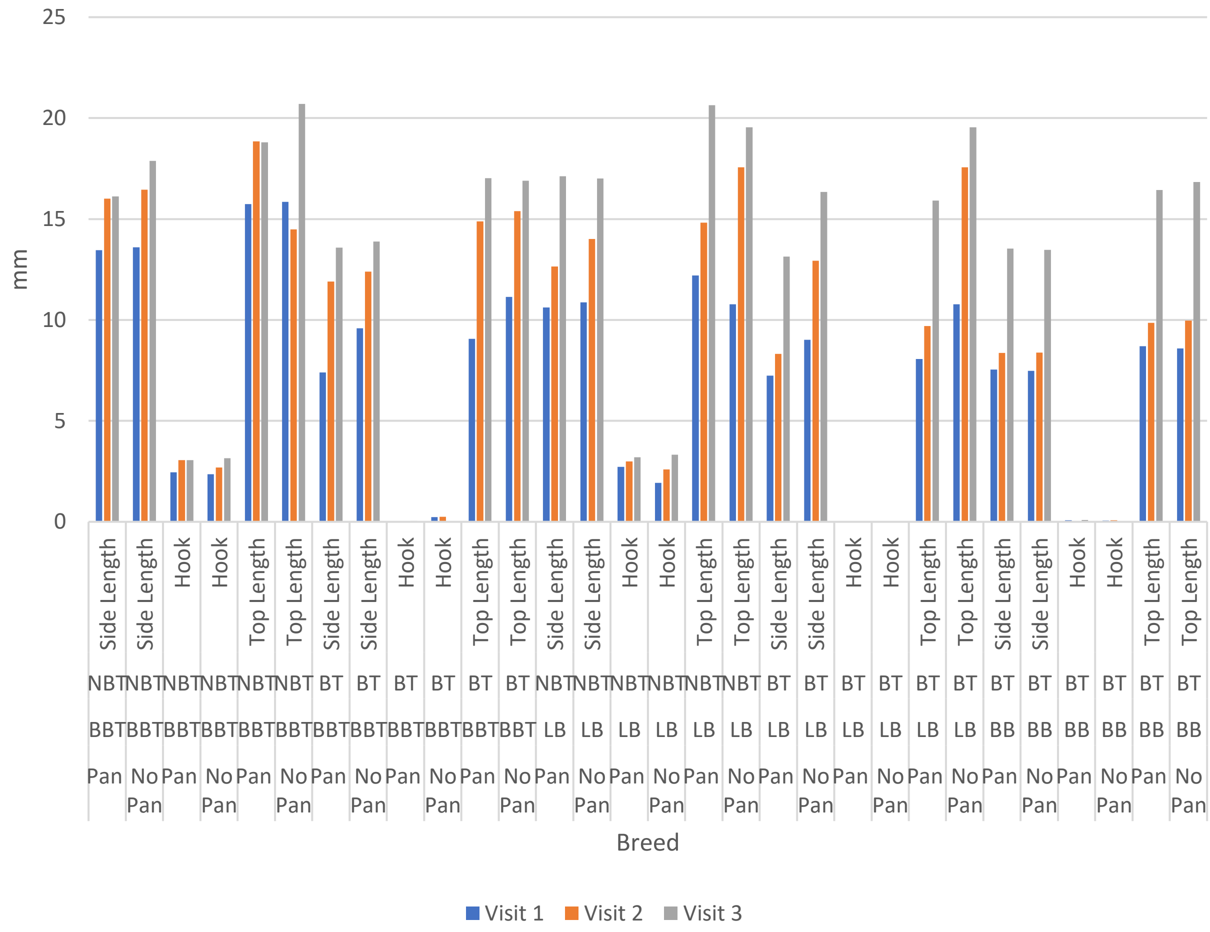


Figure 5.2 Breed effect on beak characteristics in intact and beak trimmed flocks' verses pans or no pans.

5.3 The effect of age on pecking pan usage

There was a reduction with age in pecking pan activity for the 8 flocks with access to the pecking pans with pecking activity seen more frequently in birds at the 1st visit compared to visit 2 and 3 (Visit 1 $\chi^2(2) = 75.69$, df 2, $p = 0.001$, with a mean rank score of 236.08 for visit 1, 150.04 for visit 2 and 128.38 for visit 3. There was no significant difference for visit 2 and visit 3.

Overall there was a significant difference between intact and beak-trimmed birds showing that intact beak birds used the pecking pan more Mann Whitney (U = 12.43, intact birds, n=150, Md = 0.36, trimmed birds, n = 192, Md = 0.33, p<0.31). However, there was no significant difference pecking at the pecking pan for visit 1 and visit 2.

By the 3rd visit at 14-15 weeks of age intact beak birds pecked at the pecking pan substrate more than beak trimmed flocks (U = 1.11, intact birds, n = 50, Md = 0.33, trimmed birds, n = 64, Md = 20, p<0.006).

Table 3: Pecks per 4 minutes observations in treatment flocks over the 3 visits

Flock No	Intact or BT	Breed	Visit 1 Mean (±SD)	Visit 2 Mean (±SD)	Visit 3 Mean ± (SD)
3	Intact	Lohmann Brown	51.33 (±46.45)	80.06 (±31.92)	17.05 (±20.38)
11	Intact	Lohmann Brown	31.08 (±23.22)	24.25 (±21.61)	40.75 (±24.71)
12	Intact	British Blacktails	91.00 (±40.89)	55.16 (±27.52)	51.58 (±23.94)
15	Intact	British Blacktails	79.37 (±37.72)	26.55 (±15.44)	24.87 (±20.06)
4	BT	Lohmann Brown	70.63 (±41.54)	28.18 (±37.30)	24.68 (±36.52)
5	BT	Bovans Brown	40.88 (±27.46)	23.38 (±25.78)	14.05 (±17.21)
8	BT	British Blacktails	78.12 (±65.60)	17.87 (±8.25)	29.37 (±25.33)
10	BT	British Blacktails	71.81 (±57.05)	29.37 (±24.77)	27.81 (±16.16)

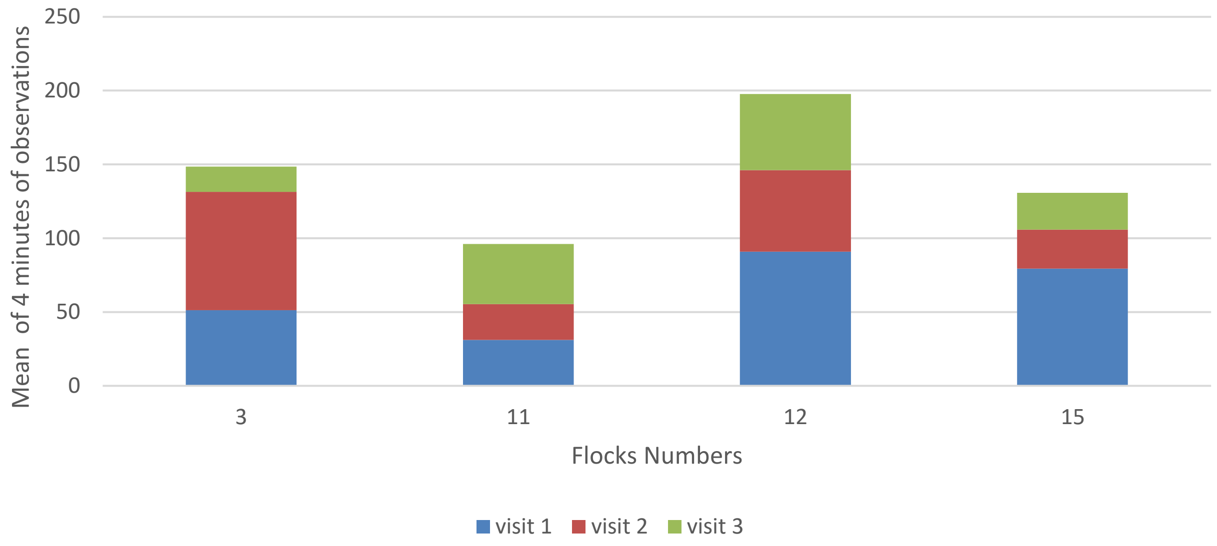


Figure 5.3 Pecks per 4 minutes observations in intact beak flocks over the 3 visits.

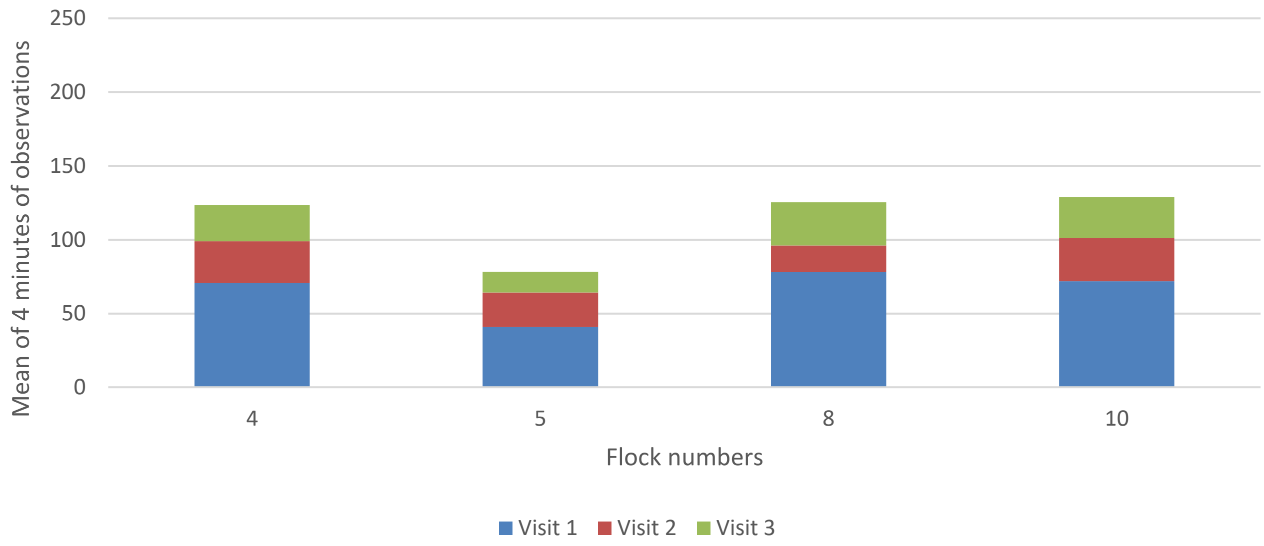


Figure 5.4 Pecks per 4 minutes observations in beak-trimmed flocks over the 3 visits.

5.4 Breed effect and age on pecking pan usage

Over all 3 visits, there was a significant difference with British Blacktail flocks pecking more at the pecking pan substrate $\chi^2(2) = 17.39$ df 2, $p = 0.001$, with a mean rank British Blacktail 199.13, Lohmann Brown 157.28 and Bovans Brown was 145.06.

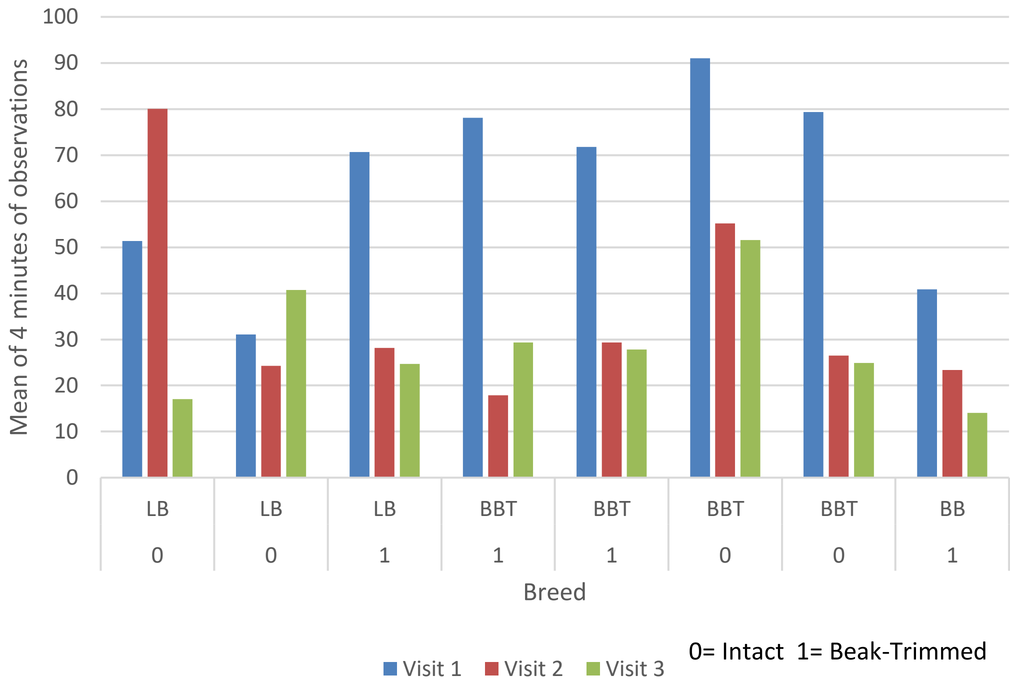


Figure 5.5: Pecking observations in intact and beak-trimmed flocks over the 3 visits.

5.5 The effect of pecking pan presence on injurious pecking

For all three visits no, significant differences in observations of injurious pecking behaviour was seen in intact beak or BT birds with or without access to the pecking pans and neither were any breed effects seen.

5.6 Visual plumage scores on intact and beak-trimmed flock

At 14-15 weeks of age there were no overall significant differences in plumage scores between intact and beak trimmed flocks.

5.6.1 The effect of pecking pan presence on visual plumage damage

At 14-15 weeks of age flocks with access to pecking pans had significantly better tail ($U = 53.86$, with pecking pan, $n = 360$, $Md = 0.00$, without pecking pan, $n = 360$, $Md = 1.00$, $p<0.015$) and wing plumage cover ($U = 57.16$ with pecking pan, $n = 360$, $Md = 0.00$, without pecking pan, $n = 360$, $Md = 1.00$, $p<0.005$). However, the presence of pecking pans did not influence plumage condition in neck, back or rump regions.

5.6.2 Breed effect on visual examinations on plumage damage

A Kruskal-Wallis H test revealed that there was a difference in plumage condition for BBT's, LB's and BB's in some body regions at 14-15 weeks. Plumage damage on the back was higher in the BBT's $\chi^2(2) = 10.66$, df2, $p = 0.005$, with a mean rank plumage score of 355.82 for BBT's, 339.83 for LB's and 336.00 for BB's. BBT's also had a higher plumage score on the tail $\chi^2(2) = 11.11$, df2, $p = 0.004$, with a mean rank plumage score of 368.51 for BBT's, 323.99 for LB's and 325.68 for BB's. There was no significant difference in neck, rump and wings between the 3 breeds.

5.6.3 Breed effect on in-depth examinations on plumage damage

There was more plumage damage seen on the tail and back of BBT's at 14-15 weeks. Kruskal-Wallis H test was higher in the BBT's $\chi^2(2) = 10.66$, df2, $p = 0.005$, with a mean rank plumage score of 355.82 for BBT's, 334.44 for LB's and 340.83 for BB's. BBT's also had a higher plumage score on tail $\chi^2(2) = 11.11$, df2, $p = 0.004$, with a mean rank plumage score of 368.51 for BBT's, 323.99 for LB's and 325.68 for BB's. There was no significant difference in neck, rump and wings between the 3 breeds.

6. Discussion

The primary aim of this research was to see whether provision of pecking pans reduced beak sharpness in intact and beak-trimmed birds. The use of pecking pans was also monitored throughout the rearing period to see if the birds maintained interest or whether it changed over time. Different methods were employed to investigate whether the provision of pecking pans thereby reduced the risk of injurious pecking and enhanced bird welfare. The secondary aims were to monitor beak growth with age during the rearing period and to consider genotypic variation by using different breeds as part of the experimental design.

The relationship between pecking pan presence on beak characteristics in intact and beak trimmed birds.

The project was successful in exploring whether the provision of a pecking enrichment device could assist in beak blunting. Overall, intact and beak trimmed flocks showed a significant difference at visit (1) at 6/7 weeks of age, with mean side length being shorter in birds with access to a pecking pan (**see fig 5.1)**. Yet, given the limitations of the measuring technique, no significant differences were found in hook or top length. However, it is unlikely that the pecking pan would have had any effect on shortening or blunting the beak as birds had limited access to it for only one day before data collection commenced. So, it is more likely to be a random effect and some other random difference between the houses on the same farms e.g. in temperature, hardness of the floor, general activity and foraging tendency of the flock, that has resulted in these differences by Visit 1. However, it could be that the pecking pans had a very rapid effect on these birds, shortening their beaks dramatically in just a few hours or days, which is not impossible. The sprinkling of corn on the pecking pan at the first visit may have been so rewarding that beaks were blunted by the continuous pecking at the pecking pan by the young chicks. It was observed by Fiks-van Niekerk and Elson, (2005) who found that intact birds with an abrasive material in a feeding trough at 6 weeks of age had shorter beaks within only a few days. The authors concluded that the beaks may have shortened so rapidly due to the newness of the abrasive material and the chicks having very soft beaks. Although, it could be considered that chicks would visit a feed trough more than a pecking enrichment to eat food. In the current study, measuring very small beaks and handling small chicks at 6/7 weeks of age proved to be somewhat difficult, particularly for measuring the hook length. A similar difficulty was mentioned by Fiks-van Niekerk and Elson, (2004) and hook measurements were abandoned from their study. The second visit, conducted when the birds were 10/11 weeks, presented positive results **(see fig 5.1)** showing a highly significant difference with side mean length and top length both being shorter in the birds presented with a pecking pan. If the pecking pans are responsible for this effect, then this may be due to the attractiveness of the pans in an otherwise barren environment (Jones, 2001, 2002). It could be considered that the pecking pans had helped shorten the top beak length as there was a notable change in beak measurements since the 1st visit at 6/7 weeks of age. This could be that some of the birds had shorter beaks before the pecking pans could have taken effect or again could be the environment around them. Again, no significance in hook length was seen, which is surprising, but it is possible that this may have become blunted or slightly rounded off if the pecking pan had been present for a longer period, or it is possible that the hook of the beak is tougher than the rest of the beak and therefore relatively unaffected. Interestingly, there was no significant difference in any of the three measurements at 14/15 weeks in any of the groups **(see fig 5.1).** As it was predicted that birds with pecking pans would have blunter beaks by the end of the rearing period, this was unexpected. One explanation is that the birds' beaks are continually growing and becoming stronger, so blunting may not have been achieved as easily as when the chicks were younger having much softer beaks. This could be tested in future by using a harder substrate and tested at older ages.

The relationship between breed effect of pecking pan presence on beak characteristics

Intact Flocks

There is limited research on measuring the effect of breed, beak characteristics and pecking enrichment objects. In this study two breeds BBT's and LB's showed significant differences with and without pecking pans **(see fig 5.2)**. The BBT's showed no significance in any of the three mean flock measurements at the first visit (1) at 6-7 weeks with a pecking pans present. Whereas differences were seen in all the 3 beak measurements being longer in the LB's that had access to the pecking pans. However, at this age, the birds have not had time to use the pecking pans. Icken *et al,* (2017) found that LB's had an upper mandible that was 0.8mm longer than LSL birds, and a lower mandible that was 0.4mm longer at 30 weeks of age. In contrast, no breed variation was seen between LB and Hyline at 64 weeks in a study by Morrissey *et al,* 2016. However, both studies (Icken *et al*, 2017 and Morrissey *et al*, 2016) measured beaks at a much older age than in our study. To my knowledge no-one else has directly compared the beak length of LB'S and BBT's. At the second visit at 10-11 weeks **(see fig 5.2**) the LB flocks demonstrated a shorter mean length in all the three measurements when birds had access to the pecking pans. This result indicates either that the birds used the pecking pans more with age or a relative effect was seen where the beaks which had the pecking pan become longer but at a much slower rate. Perhaps at the first visit the LB birds were cautious of the pecking pan but after a few weeks the birds became familiarised. There was no significant difference in **(see fig 5.2)** mean side and top length for the BBT's. However, hook length was significantly longer with birds having access to the pan **(see fig 5.2).** Therefore, it is likely the BBT's were not interested in the pan and possibly the beaks continued to grow (Fiks-van Niekerk and Elson, 2004). By 14-15 weeks of age **(see fig 5.2)** both breeds showed no significant difference in any of the three measurements if a pecking pan was present. In the LB birds the difference had disappeared by the final visit. This may be because the pecking pans had an opposite effect than we intended, possibly reducing the time the birds spent foraging elsewhere on the ground. Alternatively, beak growth may slow down as age increases. There are some similarities between these results and those of Morrissey *et al*, (2016) where laying hens were uninterested in pecking board enrichment, so it was doubtful that the pecking boards would have a chance to affect beak morphology. However, a more recent study by Morrissey *et al,* (2017) reported that cuttlebone did shorten the upper mandible of intact birds but due to brittleness of the cuttlebone it was not long-lasting in commercial flocks.

Beak-Trimmed Flocks

Interesting findings showed that there was a strong significant difference in two of the three breeds at 6-7 weeks of age **(see fig 5.2)**. Both BBT's and the LB's had a longer mean side length when there was no pecking pan available, whereas the BB birds showed no significant difference. Measurements of top length was longer with no availability of pans, but this was only witnessed in the LB birds. However, it was of interest that the BBT birds showed a significant result in a longer hook mean length when birds did not have access to the pecking pan, but this was not seen in the LB's and BB birds. However, these results are restricted as there were very few flocks of some breeds included in this study. All chicks were IRBT at a day old and breeds are trimmed at different lengths so, technically some birds were possibly trimmed shorter or trimming was not so accurate. This has been supported by previous findings that showed that the influence of beak trimming does vary with breed, procedure used and age of trimming (Fiks-van Niekerk and Elson, 2005). It is difficult to conclude from these results as the pecking pan had only been in one day previous. It is more probable that the trimming of birds varied between breeds and flocks. The data from the results demonstrates that the LB birds at 10/11 weeks of age **(see fig 5.2)** had a longer beak top and side length when no pecking pans were present. However, even if this is a significant finding we must be realistic. There are various reasons why this outcome may have only been identified in the LB birds, it could be genetics or the rearing environment. It may be the result is slightly skewed because of human or calliper error. From the present study the LB birds may have used the pecking pans more in comparison to the other two breeds BBT's and BB's, even though this was not witnessed during observations. It was identified once again that the BBT birds which did not have pecking pans to peck at had a longer hook length but no change in the other beak measurements. This could indicate the birds did peck at the pecking pan and did blunt the beak, even though these birds had been BT. Again, hook length did not differ in the LB or BB birds. The birds may be using the pecking pans and the beak is continually growing as we know is some cases it has been reported a second trim is required.

The effect of age on pecking pan activity

It is well established that environmental enrichment is beneficial during the rearing period (Jones *et al,* 2002; Blokhuis *et al,* 2001, Jones *et al,* 1998) but only a few studies have investigated the use of pecking devices such as pecking stones and blocks at rear. In this study there was a reduction with age in pecking pan activity for the 8 flocks provided with pecking pans with pecking activity seen more frequently in birds at the 1st visit compared to visits 2 and 3 **(see figs 5.3 & 5.4).** Overall in all 8 flocks the pecking pan did not sustain interest and the novelty of this enrichment soon wore off. It has been observed in broiler chicks that exploratory behaviour increased when novel enrichment was provided daily (Newberry, 1999). One possible explanation is the pecking pans may have been more interesting if the pecking pans had been placed when the chicks were younger, as it has been suggested that enrichment and suitable substrate should be provided at a day old or before 10 days if it is to retain the interest of birds as they age (Huber-Eicher and Wechsler, 1997). However, after a pilot study, it was decided to place the pecking pans when the birds were 6 or 7 weeks of age. It was felt that, in younger birds, the combination of their very soft beaks and the hardness of the substrate inside the pecking pan could potentially damage both top and bottom mandible. It could be that the chicks prefer softer enrichments which are easier to manipulate such as string, a device that has a moving or swing action or enrichment which has a food reward (Jones *et al,* 2002). As the birds in this study became older they tended to perch on top of the pecking pan, blocking access and soiling it with faeces and litter. This may have reduced the pecking motivation towards the pans. Pettersson *et al,* (2017), also found that perching activity on pecking pans increased with age and the birds lost interest because the pecking pan became soiled. A further result from this study showed that intact beak birds used the pecking pan more than beak-trimmed birds **(see fig 5.3**). Interestingly, this could show that beak trimming at a young age may result in short and long-term pain (Cheng, 2006) and result in birds that are reluctant to peck at something hard. The intact beak birds pecked more at the pecking pan as age increased. This finding supports many studies indicating that older laying hens do use enrichment. Pettersson *et al*, (2017) investigated this and found that the pecking pans had positive effects in laying hens age from 20-40 week. Weeks *et al,* (2011) also showed that older hens pecked at aerated breeze blocks. Therefore, it could be that older intact beak pullets find the pecking pan easier to peck at than much younger chicks. As Nicol *et al,* (2001) demonstrated, adult hen behaviour is flexible and adding supplementary resources can promote foraging opportunities.

Pecking pan and injurious pecking

There was no effect of pecking pans on IP behaviour throughout the three visits. This result is surprising as it was hypothesized that birds with the pecking pans would show reduced levels of Injurious pecking. This finding conflicts with other studies that show that providing some form of enrichment reduces IP during the rearing and laying period (Lambton, *et al,* 2013; Dixon *et al*, 2010, Huber-Eicher & Wechsler 1998, Blokhuis 1989). It has been considered that providing pecking material can redirect unwanted pecking behaviour (Lambton, *et al*, 2013) and fulfils foraging motivation (Dixon *et al*, 2010, Huber-Eicher & Wechsler 1998, Blokhuis, 1989). Although, the pecking pans did not reduce IP, overall rates of SFP, and AP were low. Most sheds had maintained friable litter throughout the rearing period, giving the flocks the opportunity to forage and satisfy their needs. It was observed by Huber-Eicher and Wechsler (1998) that IP was reduced in laying hen chicks when given straw and polystyrene blocks. Other studies have found that giving chicks string to peck reduced IP (Jones *et al,* 2002, Blokhuis *et al,* 2001). Similarly, in a recent study Zepp *et al*, (2018) found that laying hen chicks given pecking stones (VILPLith, pecking block (PICKBLOCK) and Lucerne bales), favoured the Lucerne bales over the harder enrichments. Yet all groups that had enrichment present saw a reduction in GFP and SFP. It could be considered that the substrate within the pecking pans may have been too hard for the chicks to peck at and GFP was an easier option. However, Pettersson *et al*, (2017) showed that pecking pans were well used and did reduce inter-bird pecking in adult laying hens. In the current study, some of the sheds were understocked allowing more room for the birds to perform foraging activity, ground scratching and dust bathing behaviour, so birds were pursuing natural behaviours perhaps to a greater extent than in other studies. One limitation relating to the result is that the flocks were only visited 3 times throughout the rearing period so relatively low numbers of behaviours were recorded. Birds were observed performing IP behaviour by an observer which may have also influenced pecking activity.

The relationship between plumage condition in intact and beak trimmed flocks

The present study overall showed no significant difference in plumage scores between intact and beak trimmed flocks. This is interesting as we would have expected that beak trimmed flocks would have had better plumage condition compared to intact birds. As we know many studies have found that beak trimmed birds do have better plumage condition (Riber, *et al*, 2017; Sun *et al*, 2014, Lambton *et al*, 2010, Fiks-van Niekerk and de Jong, 2007) despite IP activity (Blokhuis and Van Der Haar, 1989). However, only a low rate of IP was observed in this study which would relate to birds having good plumage condition. A reduction of plumage damage in some body areas was seen at 14-15 weeks of age in flocks with access to pecking pan. Our results showed less tail plumage and wing damage. This is a positive finding as young pullets commonly start to peck around the preen gland and oily feathers near the tail (Appleby *et al,* 2004). However, in the current study there was no difference in plumage condition for neck, back or rump regions in birds when the pan was present or not. In addition, we examined whether IP and plumage damage differed between the 3 breeds. In all 3 breeds plumage damage was greater for the back and tail regions. Plumage damage was higher in the BBT's, on the back and tail only. It could be that BBT birds generally perform more IP behaviour than the other two breeds even though observations of IP were reasonably low and generally all the flocks had very good plumage. This result may be because the birds performed such behaviours out of the observation period. It should also be considered that plumage damage could be associated with young birds moulting (Bestman *et al*, 2011) and can be caused by abrasion by furnishings in the shed (Icken, *et al*, 2017, Sepeur *et al,* 2015).

7. Conclusion and Recommendations.

This study has highlighted factors that are likely to be important when considering a long-lasting enrichment to enhance bird welfare. It is the first to investigate, on multiple rearing farms, the potential benefit of blunting the bird's beak naturally through normal levels of wear. This was achieved by provision of pecking pans containing an abrasive material and provided as an intended environmental enrichment. Evaluation of the results and methodology has given rise to questions to be addressed for future work based upon the improvements to the design of the pecking pan enrichment device, and to some of the methods developed in this study. The concluding results and recommendations will be summarised below.

Provision of the pecking pan did show positive results in shortening the beak at 10/11 weeks of age in both intact and beak trimmed birds but there was no significant difference at 14/15 weeks. There was a significant breed effect indicating genotypic variation in beak dimensions and BBT's pecked more at the pecking pan substrate than the other two breeds. There was a reduction with age in pecking pan activity for the 8 flocks provided with pecking pans. Further analysis revealed intact beak birds used the pecking pan more than beak-trimmed birds over all 3 visits and pecked at the pecking pan substrate more at 14-15 weeks of age. Levels of IP were low and did not vary significantly with age, breed or presence of the pan. A reduction of plumage damage in some body areas such as tail and wing was seen at 14-15 weeks of age in flocks with access to pecking pan.

Future work could focus on designing an improved or more stimulating pecking pan. Many flocks lost interest towards the end of the rearing period, so novelty is a significant factor. It could be advantageous having two different types of pecking pans during the rearing phase which may sustain interest. Perhaps, a softer pecking pan substrate with accompanying food reward (Jones *et al,* 2002) could be incorporated into the rearing houses at a much younger age (Huber-Eicher and Wechsler, 1997). Then mid-way through the rearing phase, as chicks become older and beaks become stronger, supplementary resources and a harder substrate could be added to retain interest. This might increase foraging activity and help aid beak bluntness. The pecking pan did become soiled very quickly due to birds perching on top and this may have reduced pecking activity, as also observed in the recent study by Pettersson *et* *al,* (2017). Therefore, the shape and structure need to be refined to prevent perching on top of the pecking pan.

In terms of future research to determine beak bluntness, growth and curvature it may be more valuable to investigate smaller groups of birds in a controlled environment. A limitation of this the study was having large numbers of birds in a commercial setting. If smaller numbers of birds could have been separated, we then could have used an identity tag, so the same birds would have been followed throughout all three visits giving us a better understanding of individual beak variation and growth. Nevertheless, the outcomes have been achievable in a commercial setting, and the applied relevance of this study was also a strength. Calliper measurements were reasonably successful for measuring top and side length, but it was exceptionally difficult to measure the hook length especially when the chicks were 6/7 weeks of age. As an additional part of this study further photographic images were attained for future work for an application that could process images of chicken beaks and classify them according to their sharpness.

Results from the behavioural tests gave us some understanding of the use of the pecking pans. However, as flock and house sizes were so varied it was very hard to standardise each flock with the same quantity of pecking pans so 1 pecking pan per 500 birds were distributed throughout the litter area of each rearing house. Therefore, it may be beneficial to reduce this source of variation and consider similar flock sizes and pecking pan distributions. Furthermore, performing a snap shot of welfare measures gave us an insight of IP at rear but for future studies video recording would be advantageous so birds would not be influenced by the observer.

Despite some limitations in methodology, this study demonstrates that pecking pans for chicks/pullets may provide an environmental enrichment with the potential added benefit of blunting the bird's beak naturally through normal level of wear at approximately 10/11 weeks of age. Short-term reduction might be worthwhile even though beaks re-grew and were similar at 14/15 weeks may have shown less plumage damage and fewer skin injuries due to blunter beaks, which could keep flocks healthier. Furthermore, preliminary results indicate genotypic variation in beak characteristics, which gives scope for selecting for genotypes with blunter, less damaging beaks.

8. References

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9. Appendices

VENCOMATIC ASSESSMENT

VISIT 3

1: BACKGROUND INFORMATION:

FLOCK NUMBER……………………

Date: …………………………………….

Farm Manager/s …….

Farm Address ……….

House Number……….

Phone: ………………………………………………… Mobile………………………………………………………………….

Email: ………..

Number of birds placed: …………………………………Date placed: ……………………………………………..

Breed: ………………………………………………………………. Current age of flock: ……………………………….

Intact Flock / Beaked Trimmed

2: LIGHTING PATTERN

WEEK	LIGHTS ON	LIGHTS OFF	HOURS	LUX	COMMENTS
10					
11					
12					
13					
14					
15					

2.1 What type of lighting used?..

2.2 Is dawn and dusk achieved by means of a dimmer? Yes/No

2.3 Do you use coloured light? Yes/No

3: DIET

Feed: *Mash / Crumb* Feed manufacturer and ration code……………………………………..

How many diet changes since placement...

Do you provide grit separately Yes / No Do you scatter grit in the litter Yes / No

WEEK	DIET/RATION	FEED CONSUMPTION	GRIT
10			
11			
12			
13			
14			
15			

Feeder type*:* *Chain / Pan*

Drinkers: *Nipple / Bell*

4: WEIGHT RECORDS

WEEK	NO OF BIRDS WEIGHED	EVENNESS
10		
11		
12		
13		
14		

15		

5: MORTALITY RECORDS

WEEK	NO OF BIRDS	DIED	CULL	SMOTHERS	OTHER
10					
11					
12					
13					
14					
15					

ADDITIONAL INFORMATION

Observation Area	*intervals*	*Preening*	Dustbathing	Ground Scratching	Wing Flap	Wing & Leg stretch	Body Shake	Bill Wipe	Tail Wag	Number of Birds	
	Time									Start	End

	intervals Time	*Preening*	Dustbathing	Ground Scratching	Wing Flap	Wing & Leg stretch	Body Shake	Bill Wipe	Tail Wag	Number of Birds	
										Start	End

	intervals	*Preening*	Dustbathing	Ground Scratching	Wing Flap	Wing & Leg stretch	Body Shake	Bill Wipe	Tail Wag	Number of Birds	
	Time									Start	End

Observation Area	*intervals*	*Preening*	Dustbathing	Ground Scratching	Wing Flap	Wing & Leg stretch	Body Shake	Bill Wipe	Tail Wag	Number of Birds	
	Time									Start	End

Block Interactions Scan Sampling

Pan	Location	Time	Pecking Pan/Block (Focal Birds)	Pecking Pan Plastic (Focal Birds)	Birds at Start	Birds at End	Peck at block Start	Peck at plastic Start	Peck at block End	Peck at plastic End

Block Interactions Scan Sampling

Pan	Location	Time	Pecking Pan/Block (Focal Birds)	Pecking Pan Plastic (Focal Birds)	Birds at Start	Birds at End	Peck at block Start	Peck at plastic Start	Peck at block End	Peck at plastic End

Block Interactions Scan Sampling

Pan	Location	Time	Pecking Pan/Block (Focal Birds)	Pecking Pan Plastic (Focal Birds)	Birds at Start	Birds at End	Peck at block Start	Peck at plastic Start	Peck at block End	Peck at plastic End

Block	**Minimal Activity**	**Medium Activity**	**High Activity**	**Comments**

Injurious Pecking Behaviour Observations

Flock No…….Farm………………………………….House Number……………….Date……………………….Time: …………….

Observation Area	GFP (bouts)	SFP (pecks)	VP (pecks)	CP (pecks)	AP (pecks)	Number of Birds		Objects in observation area
						Start	End	
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9								

	Area 1					Area 2					Area 3				
Bird	Neck	Back	Rump	Tail	Wing	Neck	Back	Rump	Tail	Wing	Neck	Back	Rump	Tail	Wing
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

	Area 4					Area 5					Area 6				
Bird	Neck	Back	Rump	Tail	Wing	Neck	Back	Rump	Tail	Wing	Neck	Back	Rump	Tail	Wing
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

	Area 7					Area 8					Area 9				
Bird	Neck	Back	Rump	Tail	Wing	Neck	Back	Rump	Tail	Wing	Neck	Back	Rump	Tail	Wing
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

Internal Environment

Flock No………Farm……………………………………House Number……………………Date…………………………Time: ……………..

	Noise Level (dB)	Humidity (%)		Temperature (◦C)		Ammonia (p.p.m.)		Light intensity (Lux)				Litter (100, 75, 50, 25,0 %) Litter?
		Litter	Slats or Perches	Litter	Slats or Perches	Litter	Slats or perches	Litter		Slats and perches		
A	Min Max Average											
B	Min Max Average											
C	Min Max Average											
D	Min Max Average											

BEAK MEASUREMENTS

Measurements to be taken on the Right side of the birds beaks to include photographs of the same side.

Bird	Length si	Length si 2nd	Length si 3rd	Hook -1	Hook -	Hook -	Length to	Length to	Length to	Comments
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
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27										
28										
29										
30										
31										
32										
33										
34										
35										
36										
37										
38										
39										
40										
41										
42										
43										
44										
45										

Plumage Scores

	Plumage Scores										
Bird	Neck	Back	Rump	Tail	Wing	Bird	Neck	Back	Rump	Tail	Wing
1						13					
2						14					
3						15					
4						16					
5						17					
6						18					
7						19					
8						20					
9						21					
10						22					
11						23					
12						24					

Neck	Back	Rump	Tail	Wing	Bird	Neck	Back	Rump	Tail	Wing
					37					
					38					
					39					
					40					
					41					
					42					
					43					
					44					
					45					